A SIMULTANEOUS EQUATION MODEL OF FUTURES MARKET TRADING ACTIVITY

BY

ROBERT M. BEHR

A DISSERTATION PRESENTED TO THE GRADUATE COUNCIL
OF THE UNIVERSITY OF FLORIDA IN
PARTIAL FULFILLMENT OF THE REQUIREMENTS
FOR THE DEGREE OF DOCTOR OF PHILOSOPHY

UNIVERSITY OF FLORIDA

1981

This research is dedicated to my wife, Sarah, who has provided encouragement and many hours of hard labor towards its completion. Without Sarah it is doubtful whether this dissertation would have been written. I will forever be indebted for the compassion and understanding that she has given over the past three years. I would also like to dedicate this work to my parents, who never gave up hope.

ACKNOWLEDGMENTS

The author would like to thank Dr. Ron Ward for his assistance in this research as well as the guidance received during the course of his graduate studies. Aside from the faculty advisory role, Dr. Ward has been a close personal ally which went unappreciated too often during the grueling Ph.D. ordeal. Thanks also go out to Dr. Leo Polopolus, Dr. Richard Kilmer, Dr. Jim McClave, Dr. W.W. McPherson and Dr. Jim Simpson, each of whom were very supportive as committee members. Special thanks are accorded to Ramona Rochester, Susan Howard, and Sarah Behr for their thankless efforts in putting this manuscript together.

TABLE OF CONTENTS

		Page
ACKNOWLEDGMENTS		iii
LIST OF TABLES		vi
LIST OF FIGURES		ix
ABSTRACT		xi
CHAPTER		
1	INTRODUCTION	1
	The Analogy with Money	2
	Recent Trends	4
	Economic Functions of Futures Markets	8
	Economic Problems and Concerns	12
	Statement of Objectives	17
	Methodology	17
	Overview	19
2	LITERATURE REVIEW	20
	Overview of Futures Market Literature	20
	Telser's Model	31
3	THEORETICAL FUTURES BENEFIT MODEL	38
	The Benefit Equation	38
	Exogenous Effects on Trading	46
	The Exogenous Influences	50
	Summary	64
4	A MATHEMATICAL FUTURES TRADING MODEL	66
	Variable Definitions	67
	Choice of Functional Form	93
	Mathematical Trading Model	100
	Endogenous Variable Interrelationships	103
	Summary	106
5	AN ECONOMETRIC ANALYSIS OF FUTURES TRADING	108
	The Econometric Model	108
	Empirical Futures Benefit Model	122
	Summary	137

CHAPTER		Page
6	POLICY IMPLICATIONS AND TRADING RESPONSES.	138
	The Partial Effects	138
	The Total Effects	176
	Speculative Index	186
	Summary	191
7	SUMMARY AND CONCLUSIONS.	193
	Futures Trading Overview.	193
	Futures Market Conclusions.	199
	Importance of the Research.	203
	General Conclusions	206
APPENDICES		
A	A LIST OF THE MARKETS.	209
B	DATA SOURCES	212
C	THE DATA	214
D	THE CONCENTRATED LIKELIHOOD FUNCTION	232
E	MODEL RESULTS.	236
F	THE ESTIMATION PROCEDURE	251
G	RELATIONSHIP BETWEEN NET BENEFIT FUNCTION AND MATHEMATICAL MODEL.	256
REFERENCES		258
BIOGRAPHICAL SKETCH.		262

LIST OF TABLES

Table		Page
1.1	Number of contracts traded.	6
1.2	Average monthend open interest (in contracts) . . .	7
1.3	Intertemporal movements in the coefficient of variation (CV).	9
1.4	Contract market designations: the agricultural markets	13
3.1	The hypothesized partial effects.	65
4.1	Classification of commodities by degree of perishability	87
4.2	Sign hypotheses of the Γ_{ij}.	102
5.1	First stage estimates of the logistic model using Scheme 1 allocation	123
5.2	Second stage estimates of the logistic model using Scheme 1 allocation	125
5.3	Value of the concentrated likelihood function over the range of ρ (see equation 5.11).	129
5.4	Robustness of parameters of the hedging equation with changes in ρ	130
5.5	Third stage estimates of the logistic model using Scheme 1 allocation (see equations 5.1, 5.2, and 5.3).	133
5.6	Third stage estimates of the logistic model using Scheme 2 allocation	135
6.1	The model variables with univariate statistics. . .	140
6.2	The simulated partial effects of concentration. . .	142
6.3	Concentration ratios of selected industries	144
6.4	The simulated partial effects of the coefficient of variation.	151
6.5	Effect of price support policy on cotton futures market.	155

Table		Page
6.6	Reduced form parameters based on third stage estimates using Scheme 1 (see equation 3.14).	180
6.7	Total adjustment of the speculative index and volume as age varies.	191
A.1	A list of the markets used in the empirical analysis.	209
A.2	A list of the variables used in the empirical analysis.	210
C.1	Commodity Time Series Data.	215
C.2	Commodity Time Series Data.	216
C.3	Commodity Time Series Data.	217
C.4	Commodity Time Series Data.	218
C.5	Commodity Time Series Data.	219
C.6	Commodity Time Series Data.	220
C.7	Commodity Time Series Data.	221
C.8	Commodity Time Series Data.	222
C.9	Commodity Time Series Data.	223
C.10	Commodity Time Series Data.	224
C.11	Commodity Time Series Data.	225
C.12	Commodity Time Series Data.	226
C.13	Commodity Time Series Data.	227
C.14	Commodity Time Series Data.	228
C.15	Commodity Time Series Data.	229
C.16	Commodity Time Series Data.	230
C.17	A list of the variables and their corresponding symbols	231
E.1	First stage estimates of the logistic model using Scheme 1 allocation	238
E.2	Second stage estimates of the logistic model using Scheme 1 allocation	239

Table		Page
E.3	Third stage estimates of the logistic model using Scheme 1 allocation (see equations 5.1, 5.2, and 5.3).	240
E.4	First stage estimates of the logistic model using Scheme 2 allocation	241
E.5	Second stage estimates of the logistic model using Scheme 2 allocation	242
E.6	Third stage estimates of the logistic model using Scheme 2 allocation	243
E.7	First stage estimates of the exponential model using Scheme 1 allocation	244
E.8	Second stage estimates of the exponential model using Scheme 1 allocation	245
E.9	Third stage estimates of the exponential model using Scheme 1 allocation	246
E.10	First stage estimates of the exponential model using Scheme 2 allocation	247
E.11	Second stage estimates of the exponential model using Scheme 2 allocation	248
E.12	Third stage estimates of the exponential model using Scheme 2 allocation	249

LIST OF FIGURES

Figure		Page
3.1	The effect given a change in Z.	49
3.2	The partial effect of an increase in basis risk (BR^0 to BR^1).	58
4.1	The effect of price variability on market activity.	82
4.2	The effect of age on hedging.	85
4.3	Theoretical effect of government price supports on hedging	88
4.4	Theoretical graph of the logistic function.	97
4.5	Theoretical effect of concentration on hedging. . .	99
5.1	Graph of the concentrated likelihood function for the three structural equations (HDG, SPC, and VOL).	128
6.1	The simulated partial effects of concentration. . .	141
6.2	The simulated partial effects of firm numbers . . .	146
6.3	The simulated partial effects of the correlation coefficient (CC).	148
6.4	The simulated partial effects of the coefficient of variation (CV).	150
6.5	The simulated partial effects of the loan rate variable (LN)	154
6.6	The simulated partial effects of age (AG)	158
6.7	The simulated partial effects of volume (V)	160
6.8	The simulated partial effects of the coefficient of variation (CV) with respect to speculation . . .	163
6.9	The simulated partial effects of the utility yield.	165
6.10	The simulated partial effects of volume (V) with respect to speculation.	167
6.11	The simulated partial effects of spreading (SV) . .	170

Figure		Page
6.12	The simulated partial effects of the trend variable (TT).	172
6.13	The simulated partial effects of hedging (H*) . . .	173
6.14	The simulated partial effects of exchange rank (ER)	175
6.15	Relationship between the total and partial effect of concentration (CN)	181
6.16	The relationship between total hedging open interest and total supply.	184
6.17	The total effect of concentration on hedging and speculation, respectively	188
6.18	The effect of concentration on the speculative index	189
6.19	Plot of the speculative index and volume coordinates derived from a simulation of market age . . .	190

Abstract of Dissertation Presented to the Graduate Council of
the University of Florida in Partial Fulfillment of the
Requirements for the Degree of Doctor of Philosophy

A SIMULTANEOUS EQUATION MODEL OF FUTURES MARKET TRADING ACTIVITY

By

Robert M. Behr

June 1981

Chairman: Ronald W. Ward
Major Department: Food and Resource Economics

A futures market is an institutional arrangement which evolves in response to commercial need. Futures markets facilitate forward exchange in a commodity through hedging activities conducted by commercial interests. In addition futures markets play an important role in the intertemporal allocation of stocks. More recently the forward pricing function of these markets has been emphasized with the emergence of nonstorable commodity futures markets. Hence, the futures market is more than just a place for trade futures contracts. Rather, it is an institutional arrangement that is an integral part of the broader economic environment in which the economic activity of a commodity transpires.

It was suggested that futures markets evolve or respond to commercial needs. Since the needs of commercial interests are affected by the economic environment, it follows that futures market activities will respond to the changing economic forces. One example of a changing economic environment is the change in market structure. Since the post-World

War II era there have been significant changes in market structure in many industries including agriculture. Another economic condition subject to change is the influence of government in commodity markets through price support activities.

A futures market beset by a changing economic environment will be affected through its level of use. A net benefit model was proposed that relates market net benefits to hedging, speculation and volume. The levels of these variables which maximize net benefits are optimal. Since the economic environment of markets varies cross-sectionally and intertemporally, the optimal level of hedging, speculation, and volume may differ as well.

Market power and firm size were two structural variables which were argued to influence futures market activity. The government's role in assuming commodity risk through price support activities was also thought to be influential. Other variables addressed at a conceptual level included price risk, basis risk, and the maturation process of a futures market. The conceptual net benefit model incorporated the aforementioned exogenous effects. A conceptual analysis, which showed the partial effects of these exogenous variables on hedging, speculation and volume, was conducted. The partial effects, in turn, were the basis for the hypotheses derived from the conceptual model.

A mathematical model was operationalized from the first order conditions of the theoretical net benefit function. The model consisted of three equations corresponding to three endogenous variables, hedging, speculation, and volume. Fourteen explicitly defined exogenous variables were included in the model. The exogenous variables which were used relate directly to their respective theoretical counterpart. A logistic

functional form specification was used to describe the behavioral relationships.

An econometric model was developed to estimate the parameters of the mathematical futures trading model. Pooled cross-section and time series data were used in the simultaneous equation model. Since the equations were each overidentified, an alternative to the Ordinary Least Squares estimator was desired because the estimates would not be consistent. Other problems including unequal observations on each cross-section, variance-components and contemporaneous correlation were addressed. An estimator which systematically dealt with these problems was developed and utilized to generate estimates of the structural parameters.

A major finding of this research is that industrial concentration has a quadratic effect on hedging activity. The importance of this finding is that it suggests the causal linkage between futures market activity and market structure. Empirical evidence suggesting that price supports reduce the need for hedging was shown. Markets were also observed to have a very long maturation process. A conclusion of this research is that futures markets evolve in response to the needs of hedgers which, in turn, are shaped by the dynamic forces of the economic conditions that beset commercial interests.

CHAPTER 1

INTRODUCTION

A futures market like most markets facilitates exchange. In the case of the futures market, contracts are the object of exchange. The contract is a highly standardized instrument that is traded on the exchange floor according to the rules and regulations set by the exchange. All contracts dated similarly for a specific commodity are identical, thus reducing the importance of buyer-seller identity. Impersonal trade is further enhanced by the exchange's backing of all transactions. Market entry and exit is aided via the nominal cost of transacting. In this context the futures market resembles the conceptual model of perfect competition.

An organized futures market is a voluntary association of traders who have joined together for the purpose of exchanging futures contracts. This association constitutes the members of an exchange. Membership is typically referred to as having a seat on the exchange. The seats can be sold through buyer-seller negotiations subject to membership approval. Aside from determining the integrity of potential members, the exchange is principally involved in writing the contract to be traded, establishing the rules which govern trade, and enforcing all rules and regulations. The main objective of the exchange is to provide and regulate a market place so that members and their clients can trade futures contracts for a specific commodity [Hieronymus, 1971].

The futures contract is a highly standardized contract that represents a commitment to make a future transaction. A commitment to buy (a long futures position) or a commitment to sell (a short position) need not be filled with commodity transfer. Generally the commitments are offset by entering into an opposite futures position which negates the previous open position. The typical futures contract is standardized with respect to the following dimensions:

1.) quantity to be delivered

2.) quality acceptable for delivery

3.) place of delivery

4.) time of delivery

5.) terms of payment

6.) recourse in case of injury or settlement of disputes.

All contracts are identical with respect to the above dimensions. A transaction involves agreement upon the contract price and the number of contracts exchanged. The standardization forces the focus of buyer-seller interaction to the discovery of the futures price.

The Analogy with Money

The development of futures markets in this country has paralleled the development of forward marketing. Forward dealings or forward contracting have a history as old as mercantile trade. In the U.S. forward contracting is traced back to the grain trade of the mid 19th century. In an effort to avoid price risk grain merchants holding grain over the winter months contracted ahead to sell grain to dealers in midwest terminal markets. Exchanges were established to facilitate this type of trade as well as the spot trade. The development of means of

standardization enhanced forward trade because it enabled lower transactions cost in the contract negotiations. Eventually, the futures market evolved promoting commercial trade in forward dealings by attracting hedging interest as well as a speculative interest.

The futures contract is a special case of the forward contract. A forward contract is an agreement between buyer and seller to transfer title according to the stipulations of the contract. The contract stipulations are arrived at mutually through a buyer-seller bargaining process. On the other hand futures contract stipulations with the exception of price are written by the exchange. The futures contract is traded on the floor of an organized exchange whereas the forward contract is not. For these reasons futures contracts can be obtained at a fraction of the transactions cost required of a forward contract. However, there is a limit to its commercial usefulness; namely, the more standardized the forward contract the less applicable a contract is to broad-based commercial use. This tradeoff helps to explain why both forms of marketing tools exist in the commercial trade of a commodity.

The evolution of futures markets parallels the development of money exchange as it evolved to replace barter exchange. In a highly specialized economy the transactions costs associated with barter exchange would be considerable. Taking one's wares from door to door to exchange for other consumptive items would doubtless be burdensome. An open market under such a system would also be very confusing. The number of exchange ratios required to facilitate trade is on the order of $N(N - 1)/2$, where N is the number of goods and services exchanged in an economy. Hence, the value of money as a unit of account is quite evident in an advanced economy.

The use of money depends on its acceptance as a standard of exchange. Money can represent a temporary abode of purchasing power if it is accepted as payment in exchange for goods and services. In the U.S. the dollar is acceptable nearly everywhere as a means of payment in an exchange. The dollar is as good as its federal backing, although money in an economy need not have federal backing. Nonetheless, the central government backing makes the government a third party to all transactions and a point of legal recourse to injured parties of a transaction.

The similarities between a futures market with its antecedent, forward contracting, and money exchange with the barter system it replaced are striking. The futures contract is a highly standardized commitment to transfer commodity ownership at a future date. It represents a standard of exchange in terms of the commodity. The standardization reduces the transactions cost of forward dealings since all contract attributes other than prices are predetermined. Like money the standardization of forward dealings is useful to the extent it is acceptable as a means of forward contracting. Moreover, the futures contract must have the potential for broad acceptance as a substitute for a merchandising contract. If it lacks broad acceptance the costs of organizing a market to exchange futures contracts may outweigh the benefits.

Recent Trends

Organized commodity futures trading has existed in the U.S. since the middle of the 19th century. Initially only a handful of agricultural commodities were traded on futures markets. Today a wide assortment of commodities have active futures markets. In the past two decades futures

trading began in commodity groups as diverse as foreign currencies, financial instruments, and petroleum products. New markets were also established for agricultural commodities such as live cattle, live hogs, frozen pork bellies, and frozen concentrated orange juice (FCOJ). Currently, there are 70 contract markets as designated by the Commodity Futures Trading Commission (CFTC), the regulatory body that oversees futures trading in the U.S.

Since 1960 the volume of trading on U.S. markets has increased more than tenfold (Table 1.1). Some of that increase can be attributed to the development of new markets, such as the livestock products markets and the precious metals markets. It is also apparent that the volume increased significantly on the established markets as well. For instance volume on markets in the grains group was 23.1 million contracts in 1978, an increase of nearly 20 million over an 18 year period. Included in the grains group are commodities such as wheat and corn which have been traded on futures markets since 1880. Despite the long history of these markets, volume records were set practically on an annual basis over the last two decades. The volume of trade in corn futures jumped dramatically from 336 thousand in 1960 to 6.2 million contracts in 1978. Hence, futures market activity as measured by the volume of trade has increased significantly over a broad range of futures markets including both old and recently developed markets.

Another indication of the increased activity on futures markets is the jump in the level of open interest. Average monthend commitments for all regulated markets increased from 149 thousand in 1960 to 1.37 million contracts in 1978 (Table 1.2). The increase in open interest reflects increased commercial (hedging) and speculative use. Like the

Table 1.1--Number of contracts traded

Fiscal Year	Total	Grains	Livestock Products	Foods	Industrial Raw Materials	Precious Metals	Financial Instruments	Foreign Currencies
1960	3,656,381	2,552,195	--	875,592	227,522	1,072	--	--
1970	12,398,188	5,838,881	3,431,947	1,960,894	193,177	973,289	--	--
1974	25,013,477	11,891,186	4,762,013	2,884,140	1,534,754	3,573,545	--	358,839
1975	26,283,934	13,297,832	4,764,506	2,191,398	1,318,215	4,461,615	--	250,368
1976	33,990,573	16,095,901	5,881,947	2,846,639	2,247,480	6,608,252	108,550	201,804
1977	39,747,499	20,127,703	5,632,920	2,447,436	2,779,113	7,742,471	604,622	393,234
1978	52,058,527	23,102,300	8,501,774	2,335,210	3,005,749	12,172,604	1,595,363	1,345,527

Source: CFTC DATABOOK 1978.

Table 1.2--Average monthend open interest (in contracts)

Fiscal Year	Total	Grains	Livestock Products	Foods	Industrial Raw Materials	Precious Metals	Financial Instruments	Foreign Currencies
1960	149,356	81,687	--	50,592	17,077	N.A.	--	--
1970	348,630	159,554	47,457	59,784	17,557	64,278	--	--
1974	586,732	217,678	49,958	58,713	40,600	208,343	--	14,440
1975	602,799	226,168	53,710	58,937	39,729	203,137	--	21,118
1976	857,699	291,677	66,664	69,700	73,923	338,955	2,940	13,840
1977	1,111,439	362,073	76,027	88,662	84,569	471,995	17,909	10,204
1978	1,372,022	402,677	120,711	77,125	92,968	600,356	55,607	22,578

Source: CFTC DATABOOK 1978.

volume statistics, open interest has increased across all commodity groups. Since futures traders (i.e., hedgers and speculators) desire to hold open interest, the statistics suggest the presence of dynamic forces which have affected hedging and speculative behavior in a significant manner.

Several exogenous factors that have influenced hedging and speculation are readily identifiable: they include the lessened role of government in price support activities, the expansion of export markets, the change to flexible exchange rates, and the effect of the huge increases in the price of oil. Since these factors have the effect of increasing supply and demand uncertainty, commercial interests unwilling to bear increased commodity risks seek marketing strategies such as futures trading to reduce that exposure. On the other hand speculators are attracted, according to the traditional view, because of their willingness to bear such risks. Consequently, periods of great price uncertainty should give rise to increased use of futures markets (i.e., an increased level of open commitments). Using the coefficient of variation statistic constructed from monthly cash prices of selected agricultural commodity markets as a measure of price uncertainty, it is apparent that commercial interests are facing greater levels of uncertainty relative to the early 1960s (Table 1.3). Thus, it seems that a partial explanation for the increased hedging and speculative activity is the increased uncertainty across many commodity markets.

Economic Functions of Futures Markets

Futures markets are often justified because of their role in risk reduction. Commercial interests offset price risk in the cash market with

Table 1.3--Intertemporal movements in the coefficient of variation (CV)[a]

Year	Wheat	Corn	Cotton	Live Cattle[b]	Pork Bellies[b]	Eggs
1963	2.5710	5.7749	1.3817	--	--	13.4244
1968	4.5339	5.0974	5.5715	6.2582	9.9787	5.4588
1973	17.0091	21.6141	18.1765	12.1765	12.2871	20.3372
1978	14.6620	12.6953	7.0564	13.1787	15.4263	7.8154

[a] $CV_j = \left(\sum_{i=1}^{12} (p_i - \bar{p})^2\right)^{1/2} \cdot (\bar{p})^{-1}$ (p_i = average price of commodity j in month i)

[b] The 1968 figures are actually based on 1969 data. Price information was not obtained for these markets prior to 1969.

an opposite position in the futures market. This practice is commonly called hedging. In contrast, speculative involvement in futures has drawn repeated fire over the years because of its association with the moral question of gambling. However, speculators play an important role in the risk reduction role of futures markets. The futures market facilitates the separation of commodity ownership from the production, storage, transportation, and processing functions associated with the commodity [Paul and Wesson, 1960]. Although this separation does not occur in fact, it does have the effect of permitting hedger specialization in the production, storage, and processing of the commodity without the marketing problems brought about by price uncertainty. On the other hand the implicit separation allows speculators to assume the risks of ownership without the handling of the commodity. Lower costs in commodity handling because of reduced risk increase the efficiency of commodity market with an end result of lower prices at the consumer goods level.

Working [1953] has argued that hedging in futures is not motivated by the desire to reduce risk. Rather hedging is conducted to facilitate buying and selling decisions, to allow for greater freedom of business action, and to serve as a basis for conducting storage of commodity surpluses. Working adds that business risks are likely reduced as a consequence of conducting hedging activities for one of the above reasons. Nonetheless, the hedging mechanism enhances the marketing efficiency in commodity subsectors as the commodity passes from production to consumptive use. In a period of rising marketing and distribution costs the futures market can serve as a countervailing force especially for agricultural markets where this problem has been pervasive.

The futures market is also a source of equity capital. Often loans to agriculturalists are administered contingent on marketing programs that do not carry a great deal of risk. Hence, appropriate hedging strategies are implemented to secure outside funds. The futures market indirectly causes specialization in the ownership and control of capital. It allows hedgers to control capital without owning capital. As such, resources can be put to their most productive use, increasing the efficiency of the commodity complex.

At an aggergate level the futures market is influential in the allocation of stocks over time. In the absence of a futures market stockholders would have to rely on their own price expectations and other sources of information to guide stockholding decisions. Under this scenario stockholders face increased uncertainty causing them to carry less inventory since marginal storage costs are responsive to increased risks. Consequently, a greater intraseasonal price range would be expected under a no futures market scenario. There is some empirical support for this view [Tomek and Gray, 1970].

In theory, the difference between the futures and cash price, commonly called the basis, is equal to the price of storage in the analysis of storable commodities. If the basis exceeds the cost of storage stockholders can engage in arbitrage activities by simultaneously taking a long cash position and an equivalent short futures position. Given fixed storage costs price changes on either the futures or cash market represent signals to stockholders to alter their inventories. Since speculators are willing to bear the price risks of commodity ownership, more of the commodity supply will be carried through time. Hence, the effect of the presence of futures trading on the intertemporal allocation problem is readily apparent.

For nonstorable commodities there is no allocation problem. However, the difference between the futures price of a transformed commodity and the cash price of a raw commodity input reflects a market determined price of services rendered [Paul and Wesson, 1967]. Basis changes indicate shifts in the supply and demand for such services. If there is an aberration between the basis and the cost of providing services, arbitrage opportunities would exist.

Futures markets facilitate a discovery process that is designed to yield competitively determined price. They bring the relevant information to bear on the price discovery process of a commodity that is dated. Thus, the futures price is a source of information regarding future supply and demand conditions. In theory, it is an unbiased and efficient estimate of the future spot price [Tomek and Gray, 1970]. As such, commodity activities that are dated, such as storing to a future date, benefit from the availability of this sort of information. This has particular relevance for agriculture in the wake of the increased price uncertainty on agricultural commodity markets. In summary it is clear that futures markets play an important role in the economic activity of commodity markets. The role of the futures industry in agriculture is significant given the range of agricultural commodity futures markets (Table 1.4).

Economic Problems and Concerns

The futures market is an institutional arrangement within the context of a commodity complex. A commodity complex is defined to be the structural, institutional, and legal settings which govern the economic activity from commodity production to consumption. Over time these

Table 1.4--Contract market designations: the agricultural markets

Commodity Market	Exchanges[a] With Trading In	Commodity Market	Exchanges With Trading In
Wheat	MACE, CBOT, KCBT, MGE	FCOJ	Cotton
Corn	MACE, CBOT, KCBT, MGE	Live Beef	CME, MACE
Durum	MGE	Feeder Cattle	CME
Oats	MACE, MGE, CBOT	Boneless Beef	CME
Rye	MGE	Imported Beef	NYME
Barley	MGE	Live Hogs	CME, MACE
Grain Sorghums	KCBT, CME	Pork Bellies	CME, MGE
Soybeans	MACE, MGE, CBOT, KCBT	Skinned Hams	CME
Soybean Oil	CBOT	Turkeys	CME
Soybean Meal	CBOT	Iced Broilers	CBOT
Flaxseed	MGE	Plywood	CBOT
Cotton	Cotton	Stud Lumber	CBOT, CME
Eggs	CME	Lumber	CME
Butter	CME	Potatoes	CME, NYME

[a] CBOT = Chicago Board of Trade
CME = Chicago Mercantile Exchange
NYME = New York Mercantile Exchange
MACE = Mid-American Commodity Exchange
MGE = Minneapolis Grain Exchange
KCBT = Kansas City Board of Trade
Cotton = Cotton Exchange

settings will make dynamic adjustments. Accordingly, the futures market is beset by an everchanging environment. Since the futures market is utilized by the economic agents of the commodity complex the futures market cannot be immune from a dynamic enviornment.

At this writing there is very little information regarding the relationship between a futures market and its environment. This is particularly bothersome for several reasons. In the agribusiness industries as in most industries there has been a trend toward larger firms and a decrease in firm numbers. In the wheat milling industry, for instance, the number of firms has dropped from 703 in 1958 to 340 in 1972. Industrial concentration, which measures the size of the biggest firms relative to the industry, has increased over many agricultural industries. The SIC four firm concentration ratio for the soybean milling industry has increased from 37 to 53 percent from 1958 to 1972. These numbers suggest that some commodity markets may not be as competitive as once perceived.

The problem with these trends is that futures markets depend on the competitive spot markets according to the traditional view. If non-competitive elements are present in the price dicovery process, then the role of the futures market can be questioned. Since futures contracts are rarely fulfilled by delivery, it is imperative that hedgers execute futures transactions simultaneouly with cash market transactions without causing a price effect. This insures a minimum exposure to price risk. However, with the presence of large cash positions backed by futures positions the possibility of a squeeze is heightened. Distortions often ensue which reduce the hedging effectiveness of futures markets [Paul, 1976].

The lack of research concerning the effect of concentration on futures markets results from the general lack of research in the institutional area of futures market study. A typical question in this area of study relates to the existence of futures markets for some commodities while most commodities do not support futures trading. Some authors have attempted to delineate the set of conditions which are deemed necessary for futures market evolution. See Gray [1966], Hieroynmus [1971], Paul and Wesson [1960], and Telsar and Higinbotham [1977]. The conditions which are most often cited include: 1. many buyers and sellers of the commodity; 2. the commodity must be gradeable and subject to standardization; 3. the commodity should not be too perishable; 4. the supply must flow naturally to market, not hampered by artifical constraint such as governmental actions; and 5. there must be price uncertainty. Hieronymus [1971] argued that it is difficult to impose a rigorous set of eligibility characteristics when one considers empirical evidence. For example, perishable commodities such as live cattle and live hogs have supported active futures since their establishment in the mid 1960s. In the FCOJ processing industry the number of processors was relatively low in 1978. Nonetheless, the FCOJ futures market is reasonably well used by processors and speculators alike.

From a public policy perspective the apparent void in the institutional area of futures market study is hazardous. An obvious agricultural policy that has a direct bearing on futures market activity is the price support programs. When government price supports are in effect the commodity price risk is borne in part by the public. Consequently, the need of futures trading is virtually eliminated. Whether the benefits of support policies outweigh the benefits of a market which is credited

with several important economic functions is a matter for a public forum. Unfortunately, public discussion on these matters is constrained because of the lack of research in the institutional area of futures markets. Another area of public discussion which may impact upon futures markets is antitrust policy. To the extent that large firms affect futures market activity it is clear that Federal Trade Commission policy can affect activity on a futures market serving an affected large firm.

Establishment of futures markets by private interests could be enhanced if the environmental effects were better understood. In view of the economic benefits of a futures market, government policy might be directed at a private sector means of dealing with income and price uncertainty problems as well as the problem of resource allocation. Incentives could be provided for the establishment of markets that were previously thought too risky to establish. Initial costs are typically high which may be a big disincentive, because it may take several years before active use ensues. Among the newly established markets there appears to be a maturing stage during the early periods of the market's existence. In the case of pork bellies the contract had to be rewritten to encourage commercial use [Powers, 1967]. After several years of trial and error the pork belly market finally became widely used. Other markets have not been so fortunate. The role of government in futures market development could be important in these later cases. Any kind of involvement, however, depends on a better understanding of the institutional area of futures markets.

Statement of Objectives

(1) Develop the conceptual net benefit model characterizing futures market behavior in terms of hedging open interest, speculation open interest, and volume.

(2) Investigate the cross-sectional and intertemporal influences which affect futures market behavior. Among the influences that will be investigated include market structure, government involvement in commodity markets, price risk and commodity perishability.

(3) Hypothesize the behavioral effects of dynamic adjustment in the variables which affect hedging, speculations and open interest.

(4) Develop an econometric model which can be used to test the hypotheses made in (3).

(5) Present the results showing the partial and total effects of the exogenous variables on hedging, speculation and volume.

(6) Discuss the policy and research implications which emanate from this work.

Methodology

The futures market is an evolving institution which is subject to the vicisitudes of its environment. The view that the futures market is a "given" is appropriate only for short run analysis. With the trends in the structural make-up of the agribusiness industry there are many concerns over the future of the futures industry. In the research which follows this problem will be addressed. A theoretical model will be proposed which characterizes the behavior of futures markets over time. The specific behavior implied is the activity that transpires in a market setting (e.g., volume and open interest). Hypotheses regarding

the environmental impacts that beset the institutional setting of futures market activity will be made.

A theoretical model of futures market activity is designed to facilitate an econometric investigation of futures market activity. An empirical approximation of the theoretical model will be proposed and subjected to statistical analysis. The data used for this investigation are drawn from a time series of observations covering 16 commodity markets.[1] Since this research is oriented towards agriculture the markets included are agricultural markets, only. However, the included markets differ significantly, in some cases, with regard to the structural makeup of their respective industries. This cross-sectional variation is useful because the short nature of the time series, 1961 to 1978, impedes the investigation of the structural effects.

Briefly, the econometric model that will be proposed is a three-equation model with hedging, speculation and volume appearing as endogenous variables. The exogenous variables of the model are the empirically defined influences which were suggested above. Obtaining the parameter estimates of the structural equations will facilitate the hypothesis testing. However, there are several econometric problems which make straightforward Ordinary Least Squares(OLS) estimation of the reduced form equations inappropriate. Consequently, an alternative estimator is developed and applied to the estimation of the structural parameters. The estimator resembles the three-stage least squares (3SLS) estimator, but has a modification which results from the pooling of cross-sectional data. A fuller discussion of this is deferred to Chapter 5.

---

[1] See Appendix A for a list of these markets.

Overview

Chapter 2 will be a brief look at the literature that predates the current research. In the subsequent chapter the theoretical model of futures market behavior will be proposed. Chapter 4 will be the operationalization of the theoretical model. A separate chapter will be devoted to the econometric analysis and its associated problems. This will be followed by a presentation of the statistical results and a discussion of the implications. In the last chapter a summary and conclusion will be given.

CHAPTER 2

LITERATURE REVIEW

In this chapter a review of the literature that is pertinent to the subsequent analysis will be presented. The literature is categorized into three groups: (1) the historical and evolutionary aspects; (2) the theories of hedging; and (3) the theories of speculation. Following the discussion on this literature is a section devoted to recent papers by Telser [1980] and Telser and Higinbotham [1977]. The models emanating from these papers represent a pioneering attempt at modeling futures market behavior. Since the current analysis is an extension of this work a separate section that summarizes this work, is included.

Overview of Futures Market Literature

Historical and Evolutionary Aspects

Futures markets evolved from merchandising trade that was already in existence [Hieronymus, 1971]. Irwin [1954] observed that futures contracts grew out of time contracts that were used in the merchandising of grains. Grain merchants often held inventories into the spring because the unnavigatable rivers prevented delivery to terminal markets. Time contracts more commonly called forward contracts were developed as a means of forward pricing inventories reducing the risk of adverse price movements while the stocks were held. Futures markets were organized to facilitate this sort of merchandising trade ". . . by providing uniform rules governing the transactions; standards of grade, quantities,

and delivery terms; and clearing arrangements whereby the clearing house guaranteed each contract" [Gray and Rutledge, 1971, p. 59]. Initially the futures market resembled an organized forward market where most contracts were settled by delivery. As time passed, it became apparent that futures contracts were best used as a temporary substitute for a merchandising contract. Merchants held future contracts until a merchandising contract or cash market trade, which suited specific needs, was made. Consequently, most of the contracts were fulfilled by an offsetting trade rather than delivery. The futures market did not replace the forward dealings present at this time; rather it complemented existing trade.

For a long time after trading has begun it was thought that futures trading was a speculative devise. One important fact that furthered this thinking was the lack of contract fulfillment by delivery. To some the futures market was essentially a "paper" market not serving any real economic function. However, beginning in the 1930's several published works changed the speculative focus of futures markets. Hoffman [1932] was perhaps the first to observe that open interest had a seasonal pattern that corresponded to the seasonal pattern of stocks in the grain markets. If the markets were oriented towards speculation then the open interest commitments should reach peak levels just prior to harvest, the period of the greatest uncertainty [Gray and Rutledge, 1971]. This was simply not the case as Hoffman observed. Irwin [1954] furthered this view in a study of the butter and egg markets which also showed seasonal patterns of commitments that complimented inventory accumulation and displacement.

The reason that commitments varied seasonally with stocks is that futures markets were used by hedgers to protect inventory values. The difference between the spot and futures price reflected a market determined carrying charge [Working, 1949]. As such stockholders could arbitrage the two markets and earn the carrying charge as a return for providing the storage service. The hedging business during the early years of futures trading was primarily the inventory-type hedge. As the statistics on commitments were accumulated the importance of the inventory hedging became more visible. Short hedging commitments rose to a seasonal peak as stocks were being built-up. With Working's price of storage theory the ". . . inventory hedging view of futures markets had its culmination . . . with the demonstration that the cash-futures price differential reflected a true price of storage for continuous inventory commodities" [Gray and Rutledge, 1971, p. 59). Thus the question of whose market was apparently settled nearly a century following the advent of futures trading.

Although Working [1953, 1954] and others made persuasive arguments that the futures markets evolved to meet hedgers needs, the importance of speculative involvement was not ignored. Working observed during the harvest period as stocks were being augmented there was a significant imbalance between short and long hedging. This owes to the fact that the futures markets for storable commodities were dominately used as an inventory hedging vehicle, as mentioned earlier. To facilitate contract holding by short hedgers, long speculation was required to buy the contracts. Needless to say, speculative involvement flourished as speculators jumped to take advantage of profitable opportunities on the expectation of a favorable price move. In the inventory hedging markets

it was observed that changes in long speculation paralleled the movement in net hedging which is defined as the number of contracts held by short hedgers less the number held by long hedgers. This gives support to the hypothesis that speculators accommodated hedger's transactional needs in futures trading. It is conceivable that a market could exist having balanced hedging and sufficient volume without speculative activity. However, commercial interests have forward dealings that in general do not coincide. Thus, an important role of speculative activity is to carry commodity risks facilitating the coordination of the intended exchange.

In time new futures markets were established for nonstorable commodities such as fresh eggs. Previous to the writing of a fresh shell egg contract there was extensive use of the storage egg contract by warehousemen [Gray and Rutledge, 1971]. The seasonal pattern of egg production required stocks to be carried through the winter months. Consequently, the storage egg contract provided a means to conduct inventory hedging. Technological improvement in the production of eggs, however, has all but eliminated the seasonality of egg production as current production moves directly into consumptive channels. The commercial need for a storage egg market dissipated which ultimately led to the cessation of trading in storage eggs. The emergence of a fresh shell egg contract and its continued success was a shock to many economists who believed the futures market was not suited for trade in nonstorables. This belief was fostered, in part, because intertemporal price spreads for nonstorables was not well understood unlike the case of the storable commodities.

The success of the fresh shell egg contract was followed by other perishable commodities such as live cattle, live feeder cattle, and live hogs. To explain the existence of these futures markets, new theories were needed to supplant the narrow view that markets were supported by the inventory hedging. It became clear that producers could forward price planned production through the use of futures. Processors, on the other hand, could cover forward sales or fill anticipated requirements with a long futures position thereby fixing a processing margin [Gray and Rutledge, 1971]. In the feeding of cattle, for instance, the futures contract can be used to forward price the feedlot services. Paul [Paul and Wesson, 1967] has argued that the spread between the cattle futures price and the price of its inputs reflects the price of feedlot services. This is analogous to the price of storage argument for the storable commodities. Thus, the futures market can serve the interests of those dealing in nonstorable, as well, which partially explains the existence of such markets.

The degree of perishability is one factor which was thought to affect the evolutionary process of futures markets. There are other factors which affect this process. Powers [1967] has shown the importance of the contract terms in an empirical study of the pork belly futures market. Often markets fail to attract sufficient speculation. Speculation is credited with enhancing liquidity which reduces the cost of hedging. For instance, see Gary [1966; 1967], Working [1962] or Ward [1974]. Several published articles have dealt with the importance of liquidity in market development [Gray, 1966]. There has been some discussion concerning the effects of market structure on futures market activity [Paul and Wesson, 1960]. However, empirical studies dealing with the structural question cannot be found in the literature.

Hedging Theories

The theory relating to hedging has matured significantly over the past 50 years. Initially, hedging practices were thought to be analogous to insurance [Blau, 1944]. In an effort to eliminate price risk commercial interest could enter a futures position that was equal and opposite to the cash position. An implicit assumption of this view of hedging was that the cash and futures price moved in an exact parallel correspondence. As such a loss in one market was protected by a gain in the other. This view of hedging is implicit in the normal backwardation view of intertemporal price movements [Keynes, 1923; 1930]. Hedgers are willing to pay a risk premium in order to eliminate price risk. Consequently, futures markets with a preponderence of short hedgers would have a downward biased price.

The price insurance theory was replaced by a "risk reduction" theory [Gray and Rutledge, 1971]. It was observed that cash and futures prices do not move in perfect correspondence. Although cash and futures prices are not perfectly correlated, there is a strong tendency for the prices to move together. Moreover, the variability in the basis is usually less than the cash price variance. Thus a hedged position is often less risky than an unhedged position. Markets with low basis variability relative to cash price variability are considered to be better hedging markets because of the enhanced risk reduction capability. There are several empirical studies that have investigated the hedging effectiveness of futures markets in terms of its ability to reduce risk [Dale, 1981 and Ward and Schimkat, 1979].

Gray and Rutledge [1971] make the point that many studies are vague with regard to the definition of risk. They surmised from the studies

that risk is taken to be the "statistical expectation of a unit loss." As such the marginal risk is constant which implies the possibility of negative risks. More recently, studies have incorporated the behavior of individuals faced with uncertainty in a more explicit manner. That is the assumptions regarding the decision rule under uncertainty are expressly stated.

One major theme throughout the published research of Working [1962] is the deemphasized role of risk in the motivation to hedge. Working argued that futures markets facilitate buying and selling decisions, etc. (see Chapter 1). In addition Working suggested the simultaneous nature of the decision to hold stocks and futures commitments. For example, if a favorable basis movement was expected it might prompt stockholders to augment inventories and enter a corresponding futures position. Otherwise, the decision to accumulate stocks might be delayed. This view was a significant departure from the notion that the decision to hold stocks and the decision to hedge were independent processes.

Several classes of hedgers are identified by Working. One such class is termed selective hedging which might occur if ". . . a merchant places high subjective probability on a price rise in the next period: he may then leave all or part of his inventory unhedged" [Gray and Rutledge, 1971, p. 83). Anticipatory hedging is another class identified by Working. Anticipatory hedging refers to the hedging of anticipated forward commitments. This broadened view of hedging has influenced the promulgated regulations regarding legitimate hedging practices. In 1968, for instance, cattle feeders were exempted from limits on long corn positions as well as other feed-grains because the hedging of the feed-grain requirements represents an example of an anticipatory hedge in the sense that Working had expressed.

Another approach to a general theory of hedging has been developed using the portfolio analysis approach. The alternative futures market strategies are equivalent to the assets of a portfolio. The return on each asset is assumed to be a random variable and has an associated subjective probability distribution. It is assumed that the hedger has a concave, cardinal utility function. The utility function says that the expected value of the portfolio is some function of the respective asset distributions. Maximization of the function, or the expected value, is the assumed behavior by hedgers and speculators alike. Use of the portfolio analysis and the related mean-variance approach developed by Markowitz in empirical research has been common [Rutledge, 1972; Peck, 1975]. The beauty of these conceptual models is the rigor employed in their development. These models do not necessarily contradict the earlier work of Working and the risk-reduction advocates. In fact, Rutledge [1972] has shown the compatibility of arbitrage (a descriptive term of Working's theory of hedging) and risk reduction type hedging via the portfolio model. This is not so surprising in that Working suggests that arbitrage-type hedging reduces business risks however defined.

Speculation Theories

As stated earlier it was initially thought that providing the means for speculation was the role of futures markets. There has been a history of legislative moves to ban futures trading because of the so-called speculative nature of futures markets [Hieronymus, 1971]. One of the first theories of speculation suggested that speculators provide a service to hedgers by bearing commodity risks. Keynes [1930] argued that speculators earn a risk premium as payment for such services.

This concept is tied to the price insurance hedging theory which evolved simultaneously. The theory of normal backwardation was a consequence of the risk premium-price insurance view of futures markets. Alluded to earlier, the theory of normal backwardation suggests that the current futures price is discounted to the expected cash price. The discount is the risk premium which Keynes argues must be present to attract speculation.

An implication of the theory of normal backwardation was the intra-seasonal futures price movement. In markets dominated by short hedgers it follows that the futures price is downward biased. As such the futures price would in general rise. Keynes argued that consistent long speculative positions would yield profits in the long run.

Working's [1958] theory of anticipatory prices, which states that futures prices react instantly and fully to new information, casts doubt on the normal backwardation view of speculative price movements. Working's theory suggests that futures price changes are random because new information occurs randomly. A price that is biased in an efficient market cannot persist because of profit or arbitraging potential. Working's theory of speculative prices evolved in conjunction with his work on hedging theories. Working viewed the speculator as a necessary agent to a well-functioning futures market because of the liquidity provided.

The speculative price theories emanating from the work of Keynes and Working have been put to empirical tests of one kind or another since the 1920's. A popular test that evolved sought to determine whether or not speculators could earn systematic profits as Keynes suggested. Empirical research using various sorts of simulated trading

plans have yielded mixed results. See Stewart [1949], Houthakker [1957], and Rockwell [1967]. Some have observed that large speculators make profits while small traders generally lose. The profitability of speculative positions also has implications regarding price stability. Friedman [1953] has argued that profitable speculation has a stabilizing effect on cash price.

Another type of empirical test developed was a statistical investigation of the randomness of futures price changes. Working's theory implied that the price changes on organized futures markets conformed to the random walk hypothesis. A significant number of studies have in fact rejected this hypothesis which implies some systematic price behavior. See Working [1954], Houthakker [1957], and Smidt [1965]. This suggests the presence of bias. However, a number of studies argued that systematic short run futures price behavior was not supportive of the Keynes theory of normal backwardation [Gray and Rutledge, 1971; Gray, 1967].

The view that speculation is primarily important for its impact on liquidity is now well-entrenched. The importance of liquidity is evident when one considers the bivalance of market price. Working [1962] observed in a market with a small number of buyers and sellers that the difference between the bid and ask prices was magnified. As the sample of bids and offers increases in a market setting there is a greater likelihood that this spread will narrow. A hedger, having a position in a futures market that is characterized by a small number of traders, may have to take a price concession by offering to sell at the lower bid price or asking to buy at the higher ask price in order to expedite a trade in conjunction with business activities. The virtue of futures

markets is that they allow commercial interests a great deal of flexibility with regard to forward dealings. If price concessions must be taken to expedite a futures trade then an additional cost is incurred. Working [1953] has termed this the hedging cost which is distinguished from commission charges and the opportunity cost associated with margin requirements.

The need for speculation arises immediately when one recognizes that commercial forward dealings may not coincide. Further, there may be more short hedgers than long hedgers using a given commodity futures market. As such, at any given time there may be an imbalance in hedging needs. Speculation serves to smooth the incongruities in hedging needs [Gray, 1966; 1967]. If the market attracts sufficient speculation, then hedging costs are held to a minimum. Working [1953; 1954] points out that a threshold must be passed in developing markets to ensure their survival. That is, hedging and speculation are not enough for the existence of a successful futures market. The implication is that markets require a certain degree of liquidity to guarantee survival. This point is supported by other theorists as well [Gray, 1966; Telser and Higinbotham, 1977]. It must be recognized, however, that there is nothing special about speculation that enhances liquidity. A market with a sufficient number of short and long hedgers with congruent forward needs would likely be fairly liquid. The point is that the later event is not likely to occur. Hence, there is a need for speculation in futures markets.

Liquidity is a term that has been used quite freely in the discussion of market liquidity. A rigorous definition of liquidity is not apparent in the literature. Several have developed what is called a

speculative index which is used as a proxy for liquidity [Ward, 1974; Working, 1962]. Ward argues that illiquid markets (i.e., a low speculative index) can lead to a bias in the basis of FCOJ market. Gray [1967] observes a similar effect in other so-called illiquid markets. Liquidity is often implied by the level of volume observed in a market place per unit time [Telsar and Higinbotham, 1977]. If the volume is very low the likelihood that the transactions price is the true equilibrium price is lessened. This follows because the small number of traders may not be a representative sample of the population of traders. Hence, all of the relevant information is not focused on the price discovery process. A symposium addressing pricing problems in agricultural commodity markets with a special emphasis on thin or illiquid markets is enlightening but does not offer a rigorous definition of liquidity [Hayenga, 1979].

Telser's Model

In more recent work in the area of futures markets Telser has put forth a theory of organized futures markets. Briefly, the theory purports to explain the evolution of futures markets as an institutional arrangement in commodity markets. Telser argues that the advantage of futures markets over other means of forward exchange is the low transactions cost which is a consequence of market liquidity. Telser adds that the futures market evolves if the benefits of its organization exceeds the costs. This may be self-evident but Telsar utilized the notion of net benefits to construct a mathematical model of futures market behavior. A closer look at Telser's model follows directly [Telser and Higinbotham, 1977].

A Model of Liquidity

Telser observes that futures markets are beneficial because they are liquid. As a centerpiece to the model of futures market behavior, a theory of the distribution of market clearing prices is presented to account for market liquidity. The results of this theory suggest that the asymptotic distribution of market clearing prices is normal. In addition the theory suggests the determinants of market liquidity.

Analysis of the distribution of market clearing prices begins with the assumption that traders observed in a market on any given day are a random sample from a population of traders. Potential buyers have a distribution of maximal acceptable bids and potential sellers have a distribution of minimal acceptable offers. The distributions have the following mathematical representations:

$$(2.1) \quad U(p) = \int_0^P \mu(x)dx$$

where $U(p)$ = the cumulative distribution of offers that would accept a price not less than p,

$\mu(x)dx$ = probability density function of acceptable offers.

$$(2.2) \quad 1 - W(p) = \int_p^\infty w(x)dx$$

where $1 - W(p)$ = the cumulative distribution of bids that would accept a price not more than p,

$w(x)dx$ = probability density function of maximal acceptable bids.

The asymptotic supply and demand functions (the offer and bid cumulative distributions respectively) have the expected first partials. That is $\partial U(p)/\partial p \geq 0$ and $\partial W(p)/\partial p \leq 0$. The asymptotic market clearing price is the solution to the following:

$$(2.3) \quad U(p) = 1-W(p)$$

Letting p_ε be the market clearing price, then p_ε is the solution to 2.3. Further, assume there are N bids and M offers in the sample; then a bilateral auction process yields a price $P_{M,N}$. Telser's theory asserts that as M and N become large $P_{M,N}$ approaches p_ε. Another result of the theory is that the random variable $P_{M,N} - p_\varepsilon$ has an asymptotic normal distribution with mean zero and variance σ^2 where

$$(2.4) \quad \sigma^2 = \sigma_u^2 + \sigma_w^2,$$

$$(2.5) \quad \sigma_u^2 = [1/\mu(p_\varepsilon)][U(p_\varepsilon)][1-U(p_\varepsilon)]/M$$

and $$(2.6) \quad \sigma_v^2 = [1/w(p_\varepsilon)][W(p_\varepsilon)][1-W(p_\varepsilon)]/N.$$

There are two important results which follow from this theory. First, the larger number of bids and offers the smaller is the variance. A smaller variance implies the bids and offers are clustered tightly around the equilibrium price. In other words the likelihood of a transaction taking place is enhanced. Consequently, a lower variance is expected to increase volume or alternatively enhance liquidity. Second, there exists an inverse relationship between the density function parameters (i.e., $w(p_\varepsilon)$ and $\mu(p_\varepsilon)$), and the variance. Large values of these parameters imply more homogenous bids and offers. The homogeneity of bids and offers suggests a smaller variance.

The Benefits and Costs of Futures Markets

Telser incorporates the liquidity theory into a model of futures market behavior. Market behavior is characterized by the level of open interest and the level of volume. Market participants (hedgers and speculators) desire to hold futures commitments. As such open interest is a logical candidate as a variable that measures market behavior. In order

to obtain a futures commitment an exchange must be made. The transactions that take place are important with regard to market liquidity as suggested above. An increase in the volume level reduces the costs of transacting which is beneficial to hedgers and speculators who desire to hold commitments.

These ideas are summarized in the net benefit model given below:

(2.7) $N = b-c$

(2.8) $b = b(o, \ell, E_b)$

(2.9) $c = c(o, v, E_c)$

(2.10) $\ell = (v, E_\ell)$

where

N = net benefits,

b = benefits,

c = costs,

o = open interest

ℓ = liquidity,

v = volume,

and E_b, E_c, E_ℓ = exogenous variables.

Traders benefit from holding open interest because of the transactions cost advantage of futures markets. Hence, the partial, $\partial b/\partial o$ is positive. Increased liquidity raises the benefits of the market because it reduces further the transactions cost ($\partial b/\partial \ell > 0$). Volume, especially, and open interest as well are not costless. The cost of processing transactions and accounting open positions is some positive function of the volume and open interest levels, respectively. Consequently, $\partial c/\partial o$ and $\partial c/\partial v$ are positive. Tracing the effect of an increase in volume, it

is apparent that costs increase but benefits increase also because of increased liquidity. The effect on net benefits depends on the marginal conditions of 2.7.

Telser argues that the futures market will evolve if 2.7 is positive. Furthermore, markets that do evolve have activity levels that maximize the value of the net benefit function. In other words, market behavior is optimal in that the level of open interest and volume maximize 2.7. The exogenous variables E_b, E_c, and E_ℓ are the commodity specific effects which affect net benefits. As an example, consider the uncertainty of commodity prices across markets. It is argued throughout the literature on futures markets that price risk is a factor which influences the use of futures markets. Participants dealing in commodity markets with a greater degree of price risk, however measured, benefit from the use of futures markets.

An Empirical Model

Using the conceptual net benefit model, Telser developed an econometric model that sought to explain the endogenous variables, volume and open interest. Cross-sectional and time series data were used in the single equation estimation of volume and open interest. Since the cross-sectional data were pooled it was assumed that the underlying net benefit function was of the same form across markets. Cross-sectional differences are explained by differences in the levels of the exogenous variables cross-sectionally. A problem with the cross-sectional analysis of futures market behavior is the fact that contracts of different commodities are not directly comparable. For example, the wheat contract is expressed in terms of 5000 bushels, whereas the fresh shell egg contracts are in 22,500 dozen units. Comparing levels of

activity on a contract basis is meaningless since the contract can be arbitrarily defined. Accounting for this problem, Telser multiplies the open interest and volume levels by the mean price of the commodity calculated over the 12 year sample period. Hence, all contracts are in common units (i.e., dollars).

Three different measures of commodity price risk were used as explanatory variables in both the volume and open interest equations. In addition theory suggested the use of a scale variable to account for the potential use differences across commodities. It is argued that the larger the number of potential futures market participants the greater the benefit of a futures market. If, for instance, there were only a few potential users the benefit of organizing a futures market to facilitate forward dealings would be small. This follows because a small number of potential users (i.e., the fewer the bids and offers) implies an illiquid market which is costly on a transactional basis. Further, the search costs involved in finding an appropriate forward contract would not be so great if there were only a few market participants involved in forward dealings. The level of stocks was thought as an adequate proxy for the scale variable capturing potential use. However, Telser argues that the stock variable would introduce serious measurement error. Consequently, volume was used as a proxy for the scale variable in the open interest equation while the open interest variable was used as the proxy in the volume equation.

The empirical model Telser estimates is specified as follows:

$$(2.11)\quad \log(o) = \alpha_o + \alpha_1 \log(v) + \sum_{i=2}^{4} \alpha_i X_i + \mu_1$$

$$(2.12)\quad \log(v) = \delta_o + \delta_1 \log(o) + \sum_{i=2}^{4} \delta_i X_i + \mu_2$$

where o = open interest,

v = volume,

X_i = the ith measure of price variability,

μ_j = disturbance term $j = 1, 2$.

OLS estimation was implemented on 2.11 and 2.12 although Telser admits the problem of simultaneity. The results showed that the elasticities, α_1 and δ_1, were positive as expected. This suggests that as volume increases market liquidity is enhanced which reduces the transactions costs of those who desire to hold open commitments. Consequently, more open interest will be held. In addition, one measure of price variability was found to be positive and significant in the open interest equation. The measure was the coefficient of variation computed from annual prices. The positive parameter value in the open interest equation suggests the price risk motivation to hold futures. The coefficient of variation had a negative effect on volume suggesting that price volatile markets are less liquid and accordingly more costly to use. Although there is some question concerning the depth of Telser's analysis, both from a theoretical and empirical standpoint, it provides innovative contributions to futures market research. The presentation of this research serves as a foundation for the analysis which follows.

CHAPTER 3

THEORETICAL FUTURES BENEFIT MODEL

One of the major objectives of this research is to propose a theoretical model of futures market behavior. It is argued that the market evolves if its benefits exceed the costs. Market behavior is expressed in terms of hedging open interest, speculation open interest, and volume. A net benefit model which explains the market behavior variables will be setforth. Existing or potential futures markets are cast in a dynamic commodity complex. The commodity complex is defined as the structural, institutional and legal setting in which the economic activities relating to a commodity are conducted. In fact, net benefit cannot be adequately addressed without making this distinction. The proposed model will show the effects of the economic environment on market behavior. At the chapter's conclusion a summary of the theoretical results will be given (Table 3.1). While the net benefit concept is derived from Telser's work, the present model is a significant departure in that both hedging and speculation are considered.

The Benefit Equation

Exchange members band together for the purpose of trading futures contracts. More precisely, however, the members desire to hold futures contracts; i.e., they desire to hold open interest. A futures market transaction facilitates the holding of open interest. The benefit of holding futures contracts is the transactions cost advantage relative to other means of forward exchange.

Although all traders benefit from the transactions cost advantage of futures trading, it is possible to distinguish the benefits that accrue to the two trader-types: hedgers and speculators. Hedgers specialize in the producing, processing, storage, exporting, etc. of the commodity. Hedgers complement these activities with a marketing program. Marketing activities whether they be spot exchange or forward contracting are not costless. For instance, there are transactions costs incurred by the buyer and seller in their attempt to negotiate a forward contract. In addition to the price and quantity, aspects relating to form, spatial and temporal dimensions must be considered in the bargaining process. There may be considerable search costs involved in finding an appropriate party to make a mutually acceptable contract. The transactions cost saved via the holding of futures facilitates specialization in what hedgers do best, e.g., producing, processing, etc. The futures contract serves as a temporary substitute for a merchandising transaction.

The reduction in transactions cost obtained via futures market is offset to some extent by the poor substitutability of the futures contract. In this sense, poor substitutability means the futures contract has attributes that do not perfectly coincide with the forward needs of the hedger. Since the futures contract represents a highly standardized forward agreement, it is likely that some potential users will not find the futures contract acceptable as a forward instrument of trade. However, those who find the futures contract not acceptable, say for quality differences, can nonetheless benefit from use of a futures contract. In such a case commodity dealers take on an additional risk to obtain the advantages of futures. This additional risk is commonly called basis risk (see Chapter 2).

Speculators also benefit from the low transactions cost of futures markets. Speculators provide time utility to commercial interests in their forward dealings. Since the desire to forward deal by buyers and sellers may not occur coincidentially, there will be a time gap prior to a contract agreement. Speculators can bridge the gap by assuming the open end of a contract expecting to profit when the positions are reversed. A successful speculator must be able to correctly assess commercial needs; otherwise speculators will incur losses in providing time utility. Futures markets facilitate this type of speculative activity since the cost of transacting is low. Without a standardized contract speculators bear considerable risk in forward dealings. At one extreme a forward agreement written by a commodity dealer may not be useable elsewhere. Hence, speculating on that agreement would be costly. Even if it were useable elsewhere there may be substantial search costs incurred by speculators through their efforts to provide time utility.

Speculators provide time utility to commercial interests in their quest for speculative profits. Profits depend on an accurate assessment of hedging needs. Since hedging needs are a current representation of future supply and demand conditions, the hedging role in the price formation process of futures markets is important. In markets with little or no hedging interest there is no assurance that the futures price is an unbiased estimate of the expected spot price. Since the plans of commercial interests are not brought to bear on the futures price, it is highly unlikely that a purely speculative market could price correctly [Gray, 1967]. In a market dominated by speculators it becomes more difficult to sort out the information pertinent to hedging needs. Consequently, the risk of an inaccurate assessment of hedging needs increases.

Thus, speculation in futures markets also is confronted with a tradeoff. Benefits accrue from the low cost of transacting yet speculation unbounded carries greater speculative risks.

The above arguments are summarized in the benefit equation which is implicitly written as follows:

(3.1) $B = B(H, S, L, ZB)$

where

B = benefits,

H = hedging open interest,

S = speculation open interest,

L = liquidity,

ZB = an exogenous variable.

The benefits in 3.1 represent the transactions cost advantage of futures markets. These benefits arise because futures markets are highly liquid. Ultimately, both hedgers and speculators benefit from the trade of a standardized contract on an organized market. Although no attempt is made to explicitly define the benefits that accrue to the traders from market use, it is assumed that market benefits (i.e., B in 3.1) can be expressed as a function of hedging and speculative use. Hedging and speculative use is defined as the level of hedging and speculative open interest respectively. Benefits are an increasing function of hedging and speculation but the rate of change is assumed to be diminishing (i.e., $\frac{\partial B}{\partial i} = B_i > 0$, $\frac{\partial^2 B}{\partial i i} = B_{ii} < 0$ $i = H, S$).

The appearance of the hedging and speculation variables in 3.1 is a contrast to the Telser model in which hedging and speculation open interest were not distinguished. It is argued that the composition of traders in terms of their use level is a significant factor affecting

the evolutionary process of futures markets. This argument is supported by the literature which suggests markets evolve in response to hedging needs. Moreover, successful markets require speculative participation [Gray, 1966]. Earlier it was suggested that futures markets could exist without any speculative activity. Since the forward dealings of commodity buyers and sellers may not coincide, the need for speculation immediately arises. Consequently, the benefit equations have both hedging and speculation open interest as arguments. Hedging open interest is defined as short hedging open interest plus long hedging open interest and speculation is similarly defined. It does not appear that a long or a short commitment makes a difference as far as benefits are concerned [Ward, 1974, p. 154]. As such, the long and short positions are combined yielding aggregate measures of hedging and speculative participation. Furthermore, only limited insight into the growth and dynamics of futures trading can be gained when aggregative open interest is considered. Whereas, a number of important policy questions, as will be seen, can be addressed when the types of trading activities are evaluated.

A liquidity variable, L, also appears in the benefit function. Since the degree of liquidity in a market raises or lowers transactions costs, it will have a corresponding effect on benefits. An increase in liquidity will raise the benefits of a market (i.e., $\frac{\partial B}{\partial L} = b_L > 0$). It is also assumed that $\frac{\partial^2 B}{\partial_L{}^2}$ is negative and the liquidity of a market is endogenously determined along with speculation and hedging. Telser [1980] argued that the volume of trading affects the liquidity of a market and this relationship is expressed as follows:

$$(3.) \quad L = L(V, ZL)$$

where V = volume,

ZL = exogenous variable.

The partials, $\frac{\partial L}{\partial V}$ and $\frac{\partial^2 L}{\partial V^2}$, are assumed to be positive and negative, respectively. Substituting 3.2 into 3.1 yields the following:

(3.3) $B = B(H, S, V, ZB, ZL)$

The cross partials of H, S, and V with respect to B are assumed to be positive.

It is assumed that B is of the same form across markets and over time. Benefits across markets are a result of differences in the endogenous variables (H, S, and V) as well as differences in the exogenous variables (ZB and ZL). The endogenous nature of H, S, and V owes to the fact that market evolution and propagation is determined within the system. The futures market is an institution within the broader commodity complex. If conditions of that complex are favorable the market may evolve. Hence, H, S, and V may take on positive values. The commodity complex is unique to the specific commodity. That is there are cross-sectional differences in the commodity complex across a spectrum of characteristics and these characteristics may influence futures market benefits. It is assumed that these characteristics are determined exogenously and are represented by ZB and ZL in 3.3. A discussion of these characteristics and their effect on the model is deferred to a later point in this chapter.

The Cost Function

The exchanges which facilitate futures trading in the U.S. are nonprofit organizations. Although exchanges provide a basis for members to profit, making money is not an exchange objective. Some of the principal exchange objectives include: "(1) to establish equitable principles of business conduct by members, (2) to provide an organized market place

and establish the time of trading, (3) to provide uniform rules and standards for the conduct of trading, (4) to establish uniformity of contract size and trade customs regarding quality and its establishment, time and place of delivery, and terms of payment, (5) to collect and disseminate price and market information to members and the public, (6) to provide a mechanism for the adjustment of disputes among members, and (7) to provide machinery to guarantee the settlement of contracts and the payment of financial obligations in connection with trading among members" [Hieronymus, 1971, p. 14]. These objectives if carried out are not costless. Processing the trades alone is an expensive process. To cover these costs exchanges earn income from three sources: investments, dues, and fees. Dues are paid by the exchange membership. Membership is limited by the organizational charter in many cases. Obtaining membership via the purchase of a seat on an exchange is not costless either. The value of a seat is market determined.

Exchange costs can be expected to rise with use. Assuming that a single futures market constitutes an exchange, the futures market cost function is implicitly written as follows:

$$(3.4) \quad C = C(H, S, V, ZC)$$

where C = costs,

ZC = exogenous variable.

The following assumptions are made regarding the first and second partials of the endogenous variables: $\frac{\partial C}{\partial H} = C_H > 0$; $C_S > 0$; $C_V > 0$; $C_{HH} > 0$, $C_{SS} > 0$; $C_{VV} > 0$, $C_{HS} > 0$; $C_{HV} > 0$; and $C_{SV} > 0$. The exogenous influence given by ZC may vary cross-sectionally or intertemporally. A detailed discussion on this exogenous variable will also be taken up later in this chapter.

The Net Benefit Function

Subtracting 3.4 from 3.3 yields the following implicitly defined net benefit function:

(3.5) $N = N(H, S, V, Z)$

where N = net benefits,

Z = exogenous variable(s).

For pedagogical purposes only one exogenous variable (Z) will be initially considered. Whereas, in the final model a number of exogenous effects must be incorporated into the analysis. The general results of the trading model can be illustrated with only one exogenous variable without any loss to the final results. Introducing all of the exogenous variables at this time is unnecessary and complicates the analysis.

It is assumed that futures market behavior expressed in terms of hedging, speculation, and volume is optimal if that behavior maximizes the net benefit function. Furthermore, it is assumed that futures market behavior is optimizing. It has been suggested that the optimizing criteria could be the level of activity which maximizes the value of the membership [Higinbotham, 1976]. However, the value of a seat is insignificant relative to the value of the business conducted by most members. Assuming that the net benefit function is well behaved (i.e., strict concavity) the optimal values of the endogenous variables can be easily derived. Taking the partial of N with respect to the endogenous variables and setting them equal to zero yields the set of first order conditions:

(3.6) $N_H = N_S = N_V = 0$

where $N_i = \frac{\partial N}{\partial i}$, and $i = H, S, V$.

Assuming that the second order conditions for a maximum hold, the optimal

values of the endogenous variables can be obtained by solving 3.6 simultaneously. The solution, using asterisks to denote optimal values, is written as follows:

$$(3.7) \quad H^* = H^*(Z)$$

$$(3.8) \quad S^* = S^*(Z)$$

$$(3.9) \quad V^* = V^*(Z)$$

If 3.5 is strictly concave, as assumed, the following second order conditions are implied:

$$(3.10) \quad N_{HH} < 0,\ N_{SS} < 0, \text{ and } N_{VV} < 0.$$

$$(3.11) \quad N_{HH}N_{SS} - N_{SH}N_{HS} > 0,\ N_{HH}N_{VV} - N_{VH}N_{HV} > 0, \text{ and}$$

$$N_{SS}N_{VV} - N_{VS}N_{SV} > 0.$$

$$(3.12) \quad \text{DET} \begin{bmatrix} N_{HH} & N_{HS} & N_{HV} \\ N_{SH} & N_{SS} & N_{SV} \\ N_{VH} & N_{VS} & N_{VV} \end{bmatrix} < 0.$$

Exogenous Effects on Trading

The exogenous variable, Z, may change which would affect the optimal solution (3.7 - 3.9). To ascertain the impact of such a change a comparative static analysis is presented. The total derivative of 3.6 with respect to Z gives the following:

$$(3.13) \quad \begin{bmatrix} N_{HH} & N_{HS} & N_{HV} \\ N_{SH} & N_{SS} & N_{SV} \\ N_{VH} & N_{VS} & N_{VV} \end{bmatrix} \cdot \begin{bmatrix} \frac{dH}{dZ} \\ \frac{dS}{dZ} \\ \frac{dV}{dZ} \end{bmatrix} = - \begin{bmatrix} N_{HZ} \\ N_{SZ} \\ N_{VZ} \end{bmatrix}$$

The effect of Z on each endogenous trading variable is then easily solved as shown in (3.14).

$$(3.14)\quad \begin{bmatrix} \frac{dH}{dZ} \\ \frac{dS}{dZ} \\ \frac{dV}{dZ} \end{bmatrix} = - \begin{bmatrix} N_{HH} & N_{HS} & N_{HV} \\ N_{SH} & N_{SS} & N_{SV} \\ N_{VH} & N_{VS} & N_{VV} \end{bmatrix}^{-1} \cdot \begin{bmatrix} N_{HZ} \\ N_{SZ} \\ N_{VZ} \end{bmatrix}$$

If $N_{HS} = N_{SH} = N_{HV} = N_{VH} = N_{SV} = N_{VS} = 0$, equation 3.14 simplifies to 3.15:

$$(3.15)\quad \begin{bmatrix} \frac{dH}{dZ} \\ \frac{dS}{dZ} \\ \frac{dV}{dZ} \end{bmatrix} = - \begin{bmatrix} (N_{HH})^{-1} & 0 & 0 \\ 0 & (N_{SS})^{-1} & 0 \\ 0 & 0 & (N_{VV})^{-1} \end{bmatrix} \cdot \begin{bmatrix} N_{HZ} \\ N_{SZ} \\ N_{VZ} \end{bmatrix}$$

Since the diagonal elements of the inverse matrix are negative the signs of the derivatives ($\frac{dH}{dZ}$, $\frac{dS}{dZ}$, and $\frac{dV}{dZ}$) in 3.15 will depend on N_{HZ}, N_{SZ}, and N_{VZ}, respectively. If the off-diagonal elements of the matrix in 3.14 are not equal to zero, the signs of derivatives ($\frac{dH}{dZ}$, $\frac{dS}{dZ}$, and $\frac{dV}{dZ}$) are not readily determined. Given that the cross partials of the endogenous variables (i.e., N_{HS}, N_{HV}, N_{SV}, etc.) are not zero, the derivatives have the following form:

$$(3.16)\quad \frac{dH}{dZ} = (-N_{HZ} \cdot (A_1) + N_{SZ} \cdot (A_2) + N_{VZ} \cdot (A_3))/D$$

$$(3.17)\quad \frac{dS}{dZ} = (N_{HZ} \cdot (A_2) - N_{SZ} \cdot (A_4) + N_{VZ} \cdot (A_5))/D$$

$$(3.18)\quad \frac{dV}{dZ} = (N_{HZ} \cdot (A_3) + N_{SZ} \cdot (A_5) + N_{VZ} \cdot (A_6))/D$$

where $A_1 = N_{SS}N_{VV} - N_{VS}N_{SV}$,

$A_2 = N_{HS}N_{VV} - N_{VS}N_{HV}$,

$A_3 = N_{HV}N_{SS} - N_{HS}N_{SV}$,

$A_4 = N_{HH}N_{VV} - N_{VH}N_{HV}$,

$$A_5 = N_{SV}N_{HH} - N_{SH}N_{HV},$$

$$A_6 = N_{HH}N_{SS} - N_{SH}N_{HS},$$

$$D = N_{HH} \cdot (A_1) - N_{SH} \cdot (A_2) + N_{VH} \cdot (A_3).$$

The denominator in 3.16, 3.17, and 3.18 is the determinant of the symmetric matrix in 3.13 which must be negative for the second order conditions to hold. Thus the signs of the above derivatives depend on the expressions in their respective numerators. However, unless one is willing to make assumptions regarding the signs of the cross-partials, namely N_{HS}, N_{HV}, N_{SV}, N_{HZ}, N_{SZ}, and N_{VZ}, the signs of the derivatives must be empirically determined.

The derivatives from 3.16, 3.17, and 3.18 can be decomposed into two important effects. The partial effect is the result given by 3.15 when the cross-partials, N_{HS}, N_{HV}, and N_{SV}, are assumed to be zero. It measures the change in the endogenous variable given a change in Z, ceteris paribus. On the other hand, the total effect measures the change in the endogenous variable as a result of a change in Z and a change in the other endogenous variables caused by the change in Z. In the figure below the partial effect of Z is illustrated (Figure 3.1). A change in Z from Z^0 to Z^1 shifts the N_H function outward. The partial effect of Z on the hedging first order condition is given by the vertical distance, oa. If the cross-partials of the endogenous variables are independent then the total effect and the partial effect are equivalent. In this case optimal H increases from H^0 to H^1 as a result of the change in Z.

The theoretical results obtained are very useful with regard to empirical applications. Consider the econometric estimation of the three

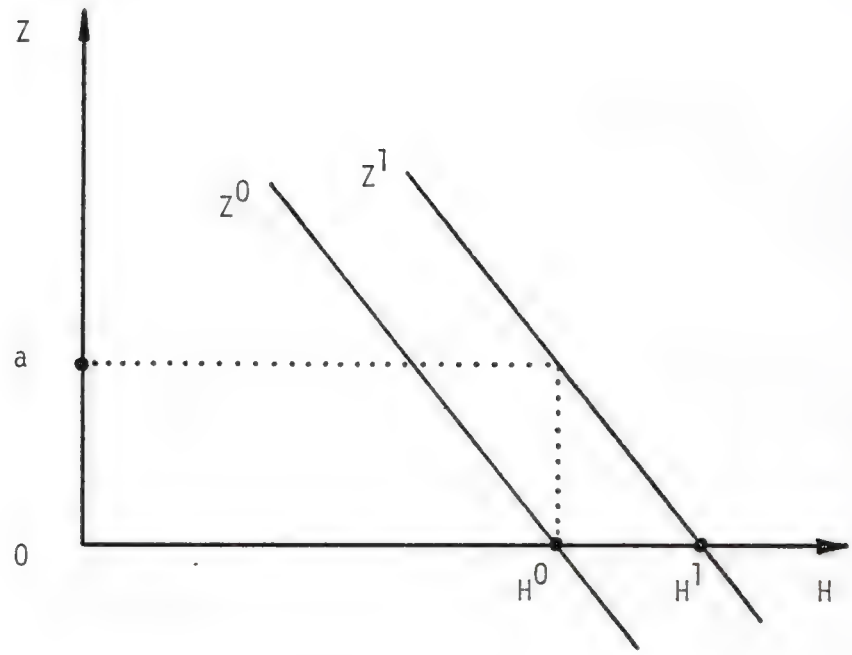


Figure 3.1--The effect given a change in Z

equation system given by 3.6. The structural parameters of this econometric problem correspond to the partial effects of the exogenous variable on the endogenous variables. On the other hand, the total effect is analogous to the reduced form parameters of this econometric system. In the empirical analysis of this study, this econometric analysis will in fact be conducted. An empirical approximation to 3.6 will be subjected to parameter estimation using an appropriate econometric technique. An objective of this research is to obtain empirical information regarding the structural parameters of the proposed system. Since the structural parameters correspond to the partial effects of Z on the endogenous variable, testable hypotheses can be made if the signs of the partial effects are known. From 3.15 it is apparent that the signs of the partial effects depend on N_{HZ}, N_{SZ}, and N_{VZ}, respectively. Knowledge of these cross-partials will depend on the specific exogenous variable in question. In the next section the exogenous variables of the model will be introduced and the discussion will center on the effect of the exogenous variable on N_H, N_S, and N_V.

The Exogenous Influences

Futures market behavior has been characterized by the net benefit function. Net benefits were argued to be some function of hedging, speculation, and volume. Since the net benefit function may not be stable over time as well as across markets, an exogenous variable Z was introduced to capture the effects of the cross-sectional and intertemporal influences. In this section these influences will be identified and the partial effects of the exogenous variables will be hypothesized.

Up to this point the exogenous effects have been discussed mathematically using Z as a representative exogenous variable. A major conclusion was that the sign of the partial effect was equivalent to the sign of N_{iZ} (i = H, S, V). The sign of N_{iZ} in turn depends on the manner in which Z interacts with the endogenous variables within the context of the net benefit function. The exogenous variables do not give rise to net benefits independently of the endogenous variables. However, the exogenous variables can affect net benefits through their impact on hedging, speculation, and volume. As such the analysis of the partial effects will concern itself with this interaction. In the subsequent discussion, exogenous variables that directly influence the trading activities are setforth.

Market Power

There is increasing evidence that market power is present in agricultural commodity subsectors [U.S.D.A., 1972]. Some of these commodities are traded on futures markets. Market power and futures trading are mutually exclusive processes [Paul and Wesson, 1960). That is, market power and futures trading are not compatible suggesting futures trading benefits decline where market power exists. To investigate this further consider a commodity that is sold by industry A and bought by industry B through spot or forward transactions. In addition, assume the existence of a futures market as an alternative means of forward exchange. In the event that industry B is a single firm (i.e., a monóposonist) there are no benefits in having a futures market. Since all the firms of industry A sell strictly to the monopsonist there are no search costs involved as far as forward dealings are concerned. Moreover, the timing

of the transaction between the sellers of industry A and the monopsonist is undoubtedly dictated by the monopsonist. Recall that the futures market facilitates the separation of ownership and control of the commodity in an illusory sense. Since the sellers have no other market outlet, the effect of the monopsonist is analogous to the futures market's role in the separation of commodity ownership from its control. In effect the monopsonist owns the commodity and extracts from the firms of industry A a monopsonistic rent for its control.

The presence of a futures market where there is a single commodity buyer also raises questions concerning the price discovery process of a futures market. A monopsonist would pose a serious threat to the possibility of a squeeze or other manipulative practices. If a market was characterized by this sort of activity short hedgers would suffer from high hedging costs because of the imminent possibility of price bias. In addition large transactions by the monopsonist may cause distortions in futures prices if there is not sufficient speculation to absorb such activity. There is also the argument that the monopsonists would prevent the development of a market because of fear that their market power would be threatened. In any case, the presence of a monopsonist buying in a market that supports a futures market seems highly unlikely. The same holds true for the case of a monopolist facing many buyers. However, this conclusion does not necessarily hold for intermediate cases of noncompetitive markets as evidenced by existence of futures markets in commodity markets having noncompetitive elements.

An imperfectly competitive market is a market where one of more buyers or sellers have a "perceptible influence" on price. This

definition is quite broad as it encompasses many different types of markets. However, most imperfect competition models are characterized by a limited number of buyers or sellers. Market power or the evidence of a noncompetitive market may also have implications regarding firm size. There may be many buyers yet the existence of one large buyer is sufficient for the presence of market power. The degree of product differentiability is also a criteria that distinguishes market competition.

Firm size is expected to have a positive effect on the net benefit function through its effect on hedging. Larger firms may relap economies in their futures trading activities. Large firms may be able to employ a specialist to handle the hedging needs of the firm. In addition large firms may have access to better information which can enhance hedging activities. On the other hand small firms may not be able to place an appropriate hedge because the contract is too large relative to firm size. Consequently small firms may not hedge at all.

In the monopsonistic case it was argued that the benefit of a futures market was dubious because price is set. For similar reasons it follows that in intermediate cases the benefit of trade in a standardized forward contract is lessened. Firms with market power would not encourage the development of an additional market outlet. Furthermore, potential manipulative effects of large firms on futures prices could deter potential hedging activity as hedging costs become enlarged. Thus, in markets that are susceptible to price effects by the actions of one or more firms the benefits of a futures market are lessened relative to an idealized case where price effects do not occur.

For most markets, the concept of market power lies in the continium from perfect competition to pure monopoly. The theory is quite clear for the extremes but less so from the range of structures lying between these extremes. While the exact quantification of these structures is at best approximate, one can argue that the usefulness of futures declines rapidly as the structure approaches the extreme point of monopolistic power. Whether the decline is continuous throughout is debatable. Use of forward markets may require some minimal level of size (e.g. management, capital, etc.) and highly atomistic structures may in fact not yield the highest level of trading. Some trading may increase with size due to economies of scale but eventually the problems resulting from increased market power must lead to an economic environment not condusive to futures trading.

The number of firms affects market benefits in another way other than its effect on the competitive price discovery process. In the monopsonistic case the exchange arrangements are greatly simplified as all sellers deal with a single buyer. An increase in the number of buyers increases the number of possible exchange arrangements. A large number of buyers and sellers having forward dealings would benefit from trade in a standardized contract on a highly liquid futures market. This follows because the search costs involved in finding an appropriate forward deal can be expected to increase as the number of exchange arrangements increase. Conversely, the benefit of a futures market when industry A and industry B have a small number of firms is not great because search costs are not great. Thus the number of firms should have a positive effect on net benefits through its interaction with the hedging variable.

Price and Basis Risk

Price risk is often cited as being a motivating factor behind the decision to enter a forward arrangement. Commodity handlers would prefer to produce, process, store, or transport the commodity rather than assume the risks of ownership. In this context risk is taken to be the uncertainty regarding the expected spot price. A rigorous treatment of risk in light of the persistent attacks will not be attempted [Gray and Rutledge, 1971]. However, the empirical measure of risk which will be presented in a subsequent chapter is consistent with applied research. Thus the only weakness is that the vagueness problem usually associated with the definition of risk is not clarified by this research. Nevertheless, it is argued that the benefits of a futures market are greater in markets that experience greater price risk. Forward contracts, once agreed upon, require the two parties to fulfill the contractual obligations including delivery. If a subsequent price drop occurs during the contract period and a further drop is expected, the buyer is placed in an unenviable position. Futures contracts are highly standardized and perfectly substitutable. As such these contracts can be exchanged to obtain a more favorable marketing position. When commodity prices are highly volatile a more flexible position is preferred. There is an implied transactions cost associated with being bound by a forward contract at least for one party to the contractual agreement. This cost is assumed to be greater in markets with greater price risk. Hence, the price risk increases the marginal effect of hedging on net benefits (i.e., $N_{HR} > 0$, where R = the degree of price risk).

Price risk is also expected to affect net benefits through its interaction with speculation. In the event futures trading was nonexistent speculation on commodity prices would probably still be evident.

Speculators could engage in such activity on a forward contract basis or outright ownership. In a market typified by price volatility there is an additional cost speculators incur. Like the case of the hedger, it might not be easy or costless to effect an immediate transaction to enter a more favorable marketing position. In highly liquid futures markets the cost of reversing an unwanted position is nominal. Thus, it is argued that price risks have a positive effect on the incremental effect of speculation on net benefits. Futures speculation primarily arises from movement of capital among alternative speculative financial instruments. Rising price variability implies greater risk but likewise greater opportunity for windfall gains. Hence, this rising opportunity should attract speculative capital in a market that otherwise has a small cost of entry and exit.

Basis risk is an important concept with regard to hedging on futures markets. In general hedgers substitute price risk for basis risk as a consequence of their hedging activities. In the ideal situation the basis tends toward zero in the delivery month of a future. If a short hedger entered a hedged position when the basis is positive and closed out that position in the delivery month when the basis is zero the hedger would have earned a positive return on the hedged commodity [Ward and Niles, 1975]. However, the basis need not be zero during the delivery month. Since there is a positive cost of delivering (or taking delivery) on a futures contract, there is a range of basis values in which the cash and futures prices may move independently of one another. Consequently, there is some risk that losses may result from an unfavorable basis when the futures position is closed. As a general rule a commodity dealer reduces the exposure to risk on a hedged commodity unit if the

basis risk is less than the cash price risk. An increase in the basis risk reduces the effectiveness of futures market with regard to risk reduction.

The partial effect of a change in basis risk is illustrated below in Figure 3.2. Assuming that the total effect and the partial effect are equivalent, an increase in basis risk decreases optimal H from H^0 and H^1. Recall that the partial effect and the total effect are equivalent if the endogenous variables are independent of one another (i.e., $N_{HS} = N_{HV} = N_{SV} = 0$). Thus, the partial effect is given by 3.15 (i.e., $\frac{dH}{dBR} = \frac{-N_{HBR}}{N_{HH}}$, where BR is defined to be a theoretical measure of basis risk). Since N_{HH} is assumed to be negative, an increase in BR reduces H. This suggests that futures markets with greater basis risk discourage hedging activities, ceteris paribus.

Maturation

Newly developed markets often pass through a phase of relative inactivity. As time passes trading increases significantly as the market develops its hedging and speculation business. Working [1953] suggested that in newly developed markets it is expensive to hedge because of liquidity problems. Sufficient speculation is required to provide the necessary liquidity to attract the potential hedging use of a futures market. It has been said that floor traders and scalpers may have to sustain losses in the start-up period to ensure the necessary level of liquidity [Working, 1962]. In other words speculators would have to make trades at prices that would otherwise not be made for the purpose of getting a market off the ground.

In this so-called start-up period of a market, there is likely to be significant information problems. These problems could result from

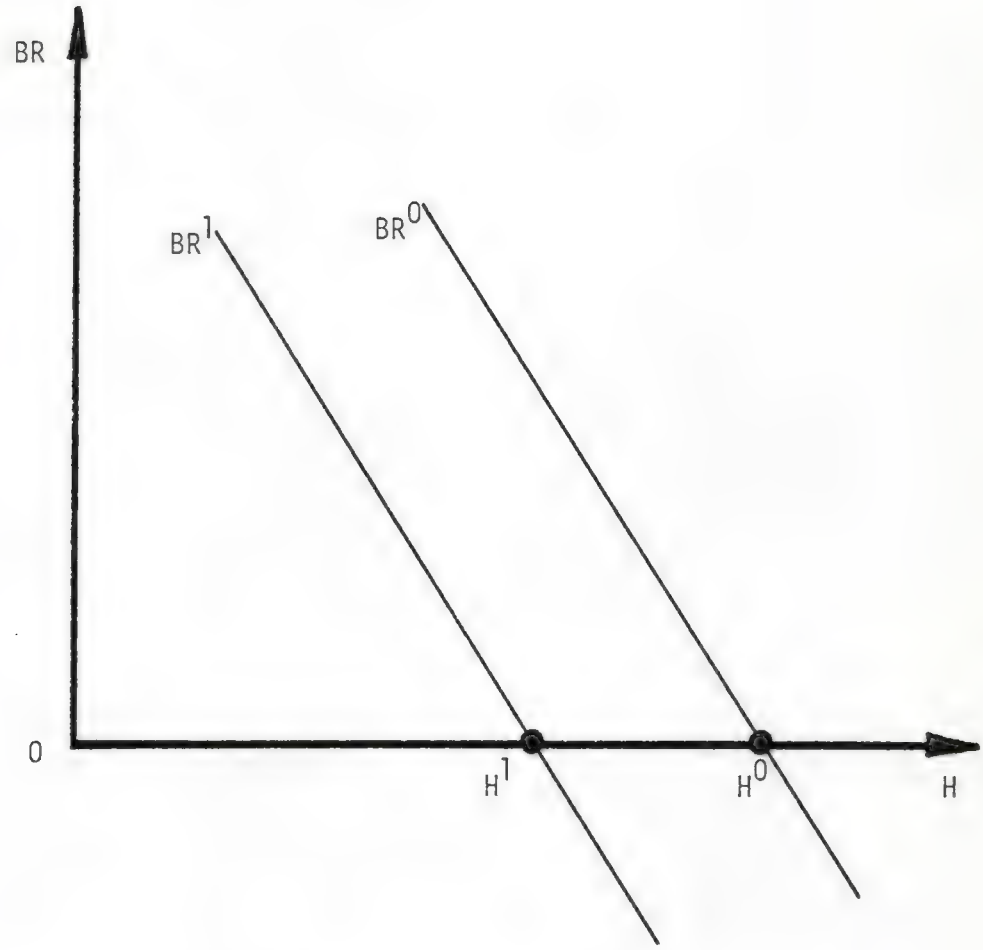


Figure 3.2--The partial effect of an increase in basis risk (BR^0 to BR^1)

the lack of understanding regarding the hedging use of the futures market. It may take years before the commercial interests understand the mechanics of using futures market to its fullest potential. Dissemination of information by the exchanges, government, academic institutions and other private concerns associated with the commodity trade tends to alleviate this problem of market development. Consequently, one can expect an increase in hedging activity as the knowledge of the potential participants, including speculators, increases. The effect of maturation on the partial of net benefits with respect to H is expected to be positive. The same holds true for maturations effect on the partial with respect to S. However, if there is a large amount of speculation initially because of the markets "newness" or because of a sacrifice to ensure market development and continued success, then the affect of maturation on the partial of S should be smaller than for hedging. For instance, if the "newness" attration wears off then speculation would be expected to decline in response to maturation. Thus the effect of maturation on speculation may be an empirical question.

Perishability and Spreading

Commodity perishability was long thought to be an impediment for a commodity to be traded on a futures market. History has proven this wrong with the successful nonstorable commodity futures markets such as fresh eggs and live cattle. Nonetheless, the degree of perishability can affect futures market behavior in several ways. Commodities that are storable can be hedged several times before the commodity is consumed. For example, producers of wheat could short hedge expected production. Upon harvest stockholders build-up inventories from the fall harvest and subsequently short hedge these stocks. Hence, the same

commodity unit could be hedged twice. Storability gives rise to additional economic functions (i.e., storage) which benefit from the presence of futures markets. Commodity futures trading in a highly storable commodity should benefit from the positive effect of storability on hedging use.

The degree of perishability can also affect the speculative trade on futures markets. The different futures contracts for a storable commodity are very similar with regard to their respective prices. Theoretically, the current price difference between any two futures is equivalent to the per unit storage cost of carrying the commodity over the time period that separates the two futures. Thus a change in one price will bring about a change in the other given a constant storage cost. In these markets speculators may opt to enter a spread position across futures of differing maturities. Since prices tend to move together a gain in one future is usually matched by a loss in the other. Speculative profits would depend on the movement of price differences while the spread was intact. Although the expected return on a spread position may be less, the risk of a spread position is also less because of the high correlation in the futures prices in storable commodity markets. Exchanges encourage spreading activity by lowering commission charges and margin requirements on spread positions. Hence, spreading activities increase speculative opportunities.

In nonstorable commodity futures markets futures of different maturities are essentially different commodities. The price of eggs for delivery in two months and the price of eggs for delivery in four months can reflect two fundamentally different sets of expected supply and demand information. Since eggs cannot be stored the price differences

between the various futures have no theoretical interpretation. Consequently, spreading in such a market may be risk increasing. As such it is argued that storability enhances speculative use of futures markets (e.g., $N_{SPE} > 0$, where PE = the degree of perishability) because of the increased speculative opportunities. It could be argued, however, that there is a given stock of speculative dollars in a given futures market and that spreading does not encourage additional speculation to enter the market. Rather spreading opportunities may shift that stock of speculative dollars from open positions to less risk spread positions. If this effect prevailed aggregate speculative use of futures markets would not be affected by commodity perishability.

Spreading also occurs across markets. Many commodities have prices that are highly correlated with one another because of a spatial, form, or substitute relationship. Price spreads between these commodities tend to be more predictable than the commodity prices. Thus speculating on price spreads across markets is less risky although the expected return may be lower as well. Lower commission charges and margin requirements are also given for intermarket spreading. Since intermarket spreading increases speculative opportunities it would seem that intermarket spreading would increase the incremental effect of speculation on net benefits. However, it is possible that intermarket spreading could siphon off speculative capital that would otherwise be spent on open positions in one market. This possibility is based on the assumption that there is a stock of speculative capital that seeks profitable alternatives. Consequently, intermarket spreading alternatives could reduce the speculative use of a given market. The effect of intermarket spreading in this case reduces the marginal effect of speculation. Thus

the partial effect of spreading on speculation is nebulous, suggesting that the effect of spreading is an empirical question.

Perishability and intermarket spreading have a similar effect on market liquidity. Recall that storable commodities have futures prices that are related intertemporally by a storage cost function. There may be intramarket spreading opportunities if the price spreads do not reflect storage costs. In other words arbitrage between the futures of different maturities would ensue. Spreading whether it be intramarket or intermarket improves the price discovery process because it increases the amount of information focused on that process. In Telser's model of the theory of market clearing prices it was observed that the homogeneity of the bid and ask prices reduced the variance of market clearing prices or alternatively increased liquidity. Prices discovered in markets with many spreading opportunities are expected to have more homogeneity of bid and ask prices because of the information regarding the price spreads. Thus a storable commodity futures market with many intermarket spreading opportunities increases the marginal effect of volume on net benefits. Storability and the presence of intermarket spreading opportunities are reinforcing effects.

Speculative Opportunity Cost

Speculative dollars can find other investment opportunities aside from the holding of futures contracts. Government securities offer rates of return that are virtually risk free. The New York stock and bond markets also compete for speculative dollars. It is argued that speculative dollars in futures markets are sensitive to alternative rates of return. As rates of return on alternative modes of investment increase speculative dollars will be drawn from futures markets, ceteris paribus. Thus,

rates of return on alternative investments will decrease the marginal effect of speculation on futures market net benefits.

Effect of Government Price Supports

A number of commodities that are traded on futures markets are included in the U.S. price support programs. Prices are generally supported by the nonrecourse loan program administered by the government. In the early and mid 1960's grain prices were relatively low. In some cases the prices were at or near the support level. It has been suggested that price support activities eliminate the need for hedging because the govenrnment assumes the risk of commodity ownership. As cash grain prices move towards the support level the risk that prices would fall much further is reduced because of the price support buffer. In this situation the need to short hedge to protect against a decline in spot prices is reduced. Thus, price support activities should have a negative partial effect with respect to hedging.

Cost Effects

The exogenous variables discussed thus far have entered the model through the benefit function or the liquidity function. There are several readily apparent exogenous variables which cause cross-sectional and intertemporal differences in the cost function. In the last two decades technological improvements in communications and microtechnology have improved the efficiency of processing trades and disseminating information. The effect of technological improvement is to increase net benefits through its positive partial effect with respect to volume. Volume is the limiting activity in a cost sense because the number of transactions that occur per time unit on one pit is physically constraining. The effect of technological improvement should affect net benefits through the volume variable rather than hedging or speculation.

There are 11 regulated exchanges in the U.S. Cost differences across markets might arise as a result of exchange size expressed in terms of volume. Larger exchanges that offer a single futures market may give rise to scale economies which would lower unit costs of market operation. Some exchanges offer trading in several futures markets. In these cases fixed costs can be spread over more markets lowering the unit costs relative to single market exchanges. These scale effects raise the incremental effect of volume on net benefits.

Summary

In the previous section the major exogenous influences were identified. This list of variables is by no means exhaustive. However, the model does not purport to explain all of the cross-sectional and intertemporal variability of hedging, speculation, and volume. The problem of this "unexplained" variability will be addressed more fully with the presentation of the stochastic model in chapter 5. Nonetheless, the partial effects of the identified exogenous variables were hypothesized. Recall that these effects are equivalent to the structural parameters of the econometric model that will be estimated. These effects serve as a basis for hypothesis testing. A major objective is to test the hypotheses regarding the conceptual model given by 3.6. The model represents the first order conditions of the net benefit function which is a mapping from futures market activity in terms of hedging, speculation and volume to net benefits. Since the futures market is cast in a dynamic environment, the parameters of the net benefit function are expected to adjust. The exogenous variables that have been introduced explain this adjustment. This adjustment is manifest in the first order conditions

and its effect on net benefits is given by the partial effects discussed above. The signs of the partial effects are summarized in Table 3.1.

Table 3.1--The hypothesized partial effects

i	N_{Hi}	N_{Si}	N_{Vi}
Firm Size (FS)	>0	=0	=0
Price Effects of Imperfect Competition (IC)	<0	=0	=0
Number of Firms (NF)	>0	=0	=0
Price Risk (PR)	>0	>0	=0
Basis Risk (BR)	<0	=0	=0
Maturation (MT)	>0	?	=0
Perishability (DP)	?	?	>0
Intermarket Spreading (IS)	0	?	>0
Opportunity Cost of Speculation (OC)	0	<0	=0
Price Supports (GE)	<0	=0	=0
Technological Improvement (TC)	=0	=0	>0
Economies of Scale (SE)	=0	=0	>0

CHAPTER 4

A MATHEMATICAL FUTURES TRADING MODEL

The purpose of the present chapter is to operationalize the conceptual model describing futures market behavior. As noted earlier one objective was to obtain empirical estimates of the parameters of the system given by 3.6. In this chapter a mathematical model of this system will be developed to facilitate the econometric analysis which follows in the subsequent chapter. In the first section of this chapter the variables of the conceptual model will be given an empirical definition. The gaps that exist between the empirically defined variables and their theoretical counterparts will be highlighted. In the next section, the functional form of the equations will be addressed. Discussion will center on the use of a logistic functional form and the corresponding implications with regard to its properties. This chapter will conclude with a presentation of the mathematical model.

Before proceeding with the model development there are several issues regarding the cross-sectional and intertemporal nature of the study that will be addressed. The time framework of the present analysis is the long run. The proposed model is attempting to explain institutional behavior. Moreover, the model seeks to explain structural influences as they relate to institutional behavior of the futures markets. Both concepts, institutional and structural change are long run concepts; whereas short run models regard the institutional and structural setting as fixed.

Long run models typically utilize annual data. It will be assumed for this analysis that a year's time is sufficient for institutional change. There are 18 years of data available for the current research. The range of structural effects on futures market behavior is limited in a study of a single commodity futures market since structural change does not occur rapidly. As such, annual data on 16 cross-sections of futures markets will be used to capture the temporal effects that are constrained by the number of observations in the time series. The cross-sectional observations also provide commodity specific information aside from the structural variation. Some of these effects which are independent of time are the commodity characteristics such as perishability. These characteristics are developed in the next section.

Variable Definitions

Hedging, Speculation and Volume

Within the context of the conceptual model hedging was defined as the total long and short open interest held by hedgers at one point in time. Speculation was similarly defined. Commitment data, which classifies the open interest as either hedging, speculation, or non-reporting are published on a semi-monthly basis [CFTC, 1978]. There are two important problems rising with the use of these data. First there are 100 or so observations on hedging and speculative open interest within a year's period. Choosing any one of the semi-monthly observation points as the annual observation of hedging and speculation may introduce seasonal hedging or speculation patterns into the model. Averaging the commitment data over the observation points would reduce the problem of seasonality. As such, the hedging and speculation open interest

variables are constructed by averaging monthly commitment data using the monthend positions.

A more serious problem with the commitment data is the fact that some of the open positions are not classified as hedging or speculative; rather these positions are classified as nonreporting. This occurs because regulations require that only large traders report their positions as being hedging or speculative. The size of the position which requires reporting varies from market to market. Nonetheless, the nonreporting proportion of open interest is often significant across all markets. Excluding the nonreporting open interest from the model would undermine the objective of explaining futures market behavior, especially when nonreporting data exceed the hedging and speculation. However, this approach is a problem too because any allocation scheme will likely be biased.

There are a few published market surveys that have classified the open positions as either hedging or speculative and some efforts to estimate all trader commitments using the data from these market surveys have been completed. See Rutledge [1977], Larson [1961] and Peck [1975]. In most studies the nonreporting data are generally treated as speculative because it is believed that there are a significant number of small speculators present in futures markets. It has been argued that there may be a tendency on the part of some speculators to have small positions to avoid reporting [Rutledge, 1977]. Hedgers, on the other hand, are less inclined to worry about the reporting and more inclined to place a hedge that optimizes some marketing strategy.

Two allocation schemes for dealing with the nonreported data will be utilized in this study. One allocation scheme allocates the nonreporting

data between hedging and speculation based on the proportion of the reported data that is hedging and speculation. That is the proportion of the nonreported data that is hedging is assumed to be equivalent to the proportion of the reported data that is hedging (Scheme 1). The second allocation procedure weights Scheme 1 by a factor which accounts for the proportion of total open interest that is nonreporting (Scheme 2). Consider the following:

$$(4.1) \quad H1 = RH + \left(\frac{RH}{TR}\right)NR; \quad S1 = RS + \left(1 - \frac{RH}{TR}\right)NR$$

$$(4.2) \quad H2 = RH + NR\left(\frac{RH}{TR}\right)\left(1 - \frac{NR}{TR + NR}\right)$$

$$= RH\left(1 + \frac{NR}{TR + NR}\right)$$

$$(4.3) \quad S2 = RS + NR\left(\left(1 - \left(\frac{RH}{TR}\right)\right)\left(1 - \frac{NR}{TR + NR}\right)\right)$$

$$= RS + NR\left(\frac{RS + NR}{TR + NR}\right)$$

where TR = total reported open interest,

NR = nonreporting open interest,

H1 = hedging open interest (Scheme 1),

S1 = speculation open interest (Scheme 1),

RH = reported hedging open interest,

RS = reported speculation open interest,

H2 = hedging open interest (Scheme 2),

S2 = speculation open interest (Scheme 2).

Under Scheme 1 allocation is based on the reported hedging and speculation levels relative to total reported open interest. Whereas, under Scheme 2 the allocation of the nonreported data is weighted in that a greater proportion is allocated to speculation. Scheme 2 follows from the assumption that as the proportion of nonreporting data increases, a

greater share of this increase arises from speculative activity. Moreover, if the assumption of Scheme 2 were valid, Scheme 1 would be biased in that too much would be allocated to hedging. In either case, however, there is no clear benchmark for evaluating the degree of bias arising from either scheme.

These methods of allocation are much more realistic than the all or nothing allocation to speculation or hedging. Since the nonreporting to total open interest ratio and the reported hedging to reported speculation ratio vary from market to market as well as over time, the above methods of allocation are unique to each market. In other words the proportion of hedging in the nonreporting data can vary across markets as well as over time. This is not the case if the proportionality factor is fixed as in the case of an all or nothing scheme or some intermediate fixed proportionality factor. Although any allocation scheme will likely be in error, a scheme that is more flexible is preferred. Hence, the allocation methods outlined above will be used in the empirical analysis that is forthcoming.

Volume is less troublesome with regard to operationalizing the variable for empirical use. Recall that volume measures the amount of contracts traded per unit time. Volume data are available on a daily basis and probably could be obtained on an intra-day basis as well. The volume variable is capturing the effects of market liquidity as an increase in volume enhances liquidity. Given that hedging and speculation are averaged daily statistics, the relevant volume statistic should also be a daily measure. This follows in that hedging and speculative activity respond to liquid market conditions which can conceivably change on a day to day basis. As such, the volume variable will be constructed

by dividing the number of trading days into total volume observed in a market for a given year. The number of trading days in a year's time is assumed to be 250.

Another problem arises because of the cross-sectional nature of the study. Specifically, the contracts across the agricultural commodity markets studied differ with respect to the unit of measure. For instance, the fresh egg futures contract calls for delivery of 22,500 dozen eggs, whereas the wheat futures contract traded at the CBOT calls for delivery of 5000 bushels. A problem arises because the trading activity in terms of contracts may not be directly comparable. Since the contract can be changed with respect to the deliverable amount, one can affect a change in market activity by arbitrarily changing the quantity parameter of a contract. There is some question as to whether contracts can be arbitrarily changed, however. Since the contracts are drafted to meet the needs of its users (i.e., hedgers and speculators), the size of the contract cannot be considered arbitrary. Moreover, contract size may also influence the liquidity and cost of a market. For instance, if the wheat contract called for delivery of one bushel of wheat, hedging would increase 5000 fold to meet current hedging needs. It is questionable that a market could physically handle the implied increase in futures market use. Thus if one accepts the proposition that contract size is not arbitrarily determined then it appears that contracts of commodities measured in different units could be compared.

The above debate on contract comparability will not be resolved by this research. A method will be adopted that allows comparability across markets. One possible method is to express the contracts in value terms.

In other words multiply the commodity units of the contract by the commodity price which would yield the contract value [Telser, 1980]. This approach would be valid if the analysis was a cross-sectional study of futures markets. However, this study includes a time series component which implies commodity price variability. The measured changes in hedging, speculation, or volume may result from price changes over time rather than real changes in futures market activity. Expressing the endogenous variables in value terms introduces price effects which makes the analysis of real futures market activity more difficult.

An approach that avoids the problems associated with value comparability is to express hedging, speculation, and volume as a percent of potential futures market use. In this manner the endogenous variables would be pure numbers expressed in percentages and could be comparable across markets. Potential use is argued to be relatively stable over time. Consequently, changes in the percentages reflect changes in actual use which is the behavior that is to be explained. Unfortunately, potential use, which is defined to be the maximum number of contracts that could be held on the average by hedgers, is not precisely measurable. A proxy for potential use is the total commodity supply observed in a given year. The total commodity supply should bear a close relationship to the quantity that is potentially hedgeable. Not all of the commodity supply is hedgeable because producing firms may be too small; the commodity is forward contracted; or for other reasons. However, it is assumed that the potential hedging proportion of total supply is constant for a market across time.

Markets are significantly different with regard to potential use. Actual use of futures markets by hedgers in a market that has ten times

the potential use of a smaller market is expected to be larger than the actual use of the smaller market. This follows because established markets should have similar use patterns relative to some potential. Thus, in a cross-sectional study of markets with significant differences in potential use there will be scaling problems. The virtue of expressing hedging, speculation, and volume as a percent of the potential use follows since the percentage eliminates the problem of contract comparability and the scale effect problem is circumvented.

Concentration and Firm Numbers

In the theory chapter it was argued that firms having market power could eventually be detrimental to futures market activity. In addition, firm size was expected to have a positive influence on hedging activities because larger firms could specialize in futures trading activities. A commonly used variable in empirical research that is used as a proxy for the aforementioned structural characteristics is concentration. Highly concentrated industries indicate the presence of noncompetitive elements. There are several ways concentration can be measured. The most common measure is the proportion of the industry's value of shipments accounted for by the largest 4, 8, 12, or 20 firms. This measure ranges between 0 and 1.0 with the largest values representing the more concentrated industries. Concentration data are published once every five years by the Bureau of Census of Manufacturers. The data are classified according to a 4 or 5-digit Standard Industrial Classification (SIC) code. A given 4 or 5-digit code refers to industry grouping with the fewer digit codes having more aggregative data [USDC, 1972].

Using concentration as a proxy for the effect of firm size and the price effects of imperfect competition is not without its difficulties.

One difficulty is the fact that larger firms and the price effects of imperfect competition imply a highly concentrated industry. However, the effects of these market power characteristics on hedging activity are diametrically opposed. Recall that $N_{HIC} < 0$ and $N_{HFS} > 0$. It is possible to reconcile these opposing effects by hypothesizing a quadratic relationship between hedging and the level of concentration. At low concentration levels the price effect of firm activities is perhaps negligible. On the other hand, firms may become large enough in low concentrated industries to reap scale economies in the use of futures as a hedging vehicle. Hence, concentration would have a positive effect on hedging activities. As the level of concentration increases, firm size increases as well. In addition, the price effects of imperfect competition may have greater presence, but concentration would have a positive effect on hedging if the firm size effect dominated the price effect. At higher concentration levels the price effects of imperfect competition increase hedging costs off-setting the positive firm size effect. Hence, at high concentration ratios the effect on hedging is strictly negative.

In the theory chapter a model of a market was developed to facilitate the discussion on market power. In that commodity market model industry A sold to industry B via spot or forward exchange which included futures trading as an alternative. The hedgers in that commodity market model were the firms of industry A (short hedgers) and the firms of industry B (long hedgers). One could use the concentration ratios of industry A and industry B to investigate the effect on the long and short hedging activities. However, this model is at a fairly high level of abstraction. Some commodities have more than one use. Consequently,

there may be several industries acting as buyers in the cash and futures markets. The storage function for storable commodities is complimented by short hedging activities which is also the hedging strategy employed by commodity producers. Since commodity users may stockpile their commodity needs and place short hedges, the number of potential commodity sellers is far greater than the number of producers. Hence, there may be a large number of industries using any one futures market. This makes the analysis of the effects of concentration more difficult.

In this study a simple approach to ascertaining the concentration effects will be adopted. Rather than include all the concentration information regarding the industries that use futures markets in the model, only one piece of concentration information will be used. The piece of information used is not arbitrarily chosen, however. The effects of concentration on hedging will not be pronounced if a concentrated industry makes minimal use of the futures market. Moreover, the concentration ratios for many agricultural commodity producers are very small, probably approaching zero in many cases. Concentration information regarding nonconcentrated producers does not contribute very much to the understanding of the concentration effects. This is particularly true when the buyers are relatively concentrated because concentration effects are present despite the competitive structure of the suppliers. It follows that the concentration of the buyers is more relevant in the case where market power is a buyer-side problem. In many agricultural industries market power is a buyer-side problem as commodity processing industries have tended towards fewer firms and greater levels of concentration. However, the buyer side concentration data that are available are output measures of concentration rather than an input measure

which is needed. For this analysis it will be assumed that the output measure is a proxy for buyer concentration in the buyer's industry. The concentration ratio that will be used in the analysis is the largest concentration ratio of the industries which make active hedging use of a particular futures market. This ratio is a proxy for buyer or seller concentration whichever is largest for a given market.

Earlier it was mentioned that concentration data are published once every five years. Hence, there are missing concentration values during the years 1961 through 1978 which is the sample period for the analysis. For estimation purposes these missing values will be replaced by actual concentration numbers. The problem that arises is the choice of numbers one could use to replace the missing values. One possibility is to assume that concentration makes a discrete jump every five years as the intervening years show concentration levels that equal the most recently published statistic. A preferred alternative is to assume that concentration levels adjust during the intervening years. A procedure which permits adjustment is to linearly interpolate the data between observed data points. This procedure is conducted as follows:

$$(4.4) \quad INC = (CO_t + CO_{t+5})/5$$

$$(4.5) \quad CO_{t+i} = CO_t + INC \qquad i = 1, 2, 3, 4$$

where INC = the annual interpolated adjustment in the level of concentration,

CO_t = concentration ratio observed in period t,

CO_{t+5} = concentration ratio observed in period t+5,

CO_{t+i} = calculated concentration ratios for years t+i.

If an end point is not available (i.e., CO_t or CO_{t+5}) then a linear extrapolation is made. Say that CO_{t+5} is not available because concentration ratios were last published in CO_t. In this case the adjustment is calculated as follows:

$$(4.6) \quad INC_E = (CO_{t-5} + CO_t)/5$$

where INC_E = the annual extrapolated adjustment in the level of concentration for the years following t.

Like the case of market power, a similar empirical problem is faced with the firm numbers variable. The number of firms that could use the futures market as a hedging device is an unknown quantity. Typically, there are a large number of producers of commodities that are traded on futures markets. Many of these producers cannot use the futures market because of size limitations and/or the market does not provide a good hedge. Consequently, the number of firms that could use the market among agricultural commodity producers is not known in general. The same problem arises for agricultural processing industries. Although statistics on firm numbers are readily available at the processor level, the exact number of firms that could use the futures market is not known. A survey of the commodity handlers, including producers, is needed to derive a reasonable estimate of the number of firms using (or potentially using) the futures market for hedging purposes. Leuthold [1975] has conducted a regional survey which investigated the actual and potential use of the live cattle futures market. However, this appears to be the only empirical study found in the literature that concerns itself with the measurement of potential firm use.

It was observed that firm numbers affect the transactions cost of exchange, whether it be forward or spot. In addition the transactions

cost is some function of the number of buyers and the number of sellers. An increase in the number of buyers increases the number of possible exchange arrangements. Likewise an increase in the number of sellers increases the number of exchange arrangements. If there are m sellers and n buyers then the number of possible exchange arrangements is m x n. The effect of an change of m and n on m x n is n and m, respectively. An incremental change of the smaller of m or n has the largest effect on the total number of possible exchange arrangements. In most agricultural markets the number of sellers is very large relative to the number of buyers. Consequently, an incremental change in the number of buyers will have a profound effect on the transactions cost of forward dealings. Thus, the information associated with the buyer side of these markets should be "richer" with regard to the effect of firm numbers.

In the discussion of concentration the point was raised that there are many industries using a given futures market. Usually, there are dominant hedging users of futures markets. Feedlot operators, for instance, are without question the dominant hedgers on the long side of the feeder cattle market. A change in the number of feedlot operators will affect the cost of forward dealings which will have a consequent affect on hedging activities. The proxy for the firm number variable that will be used in this analysis will be the number of firms in the industry that is the dominant long hedger in a given market. It is assumed that the proportion of these firms that could use the futures market is fixed. Hence, changes in firm numbers bring about a proportional change in the potential users. In addition, the implicit assumption is made that the firm numbers of the dominant buying industry are proportional to all buyer firms. Thus changes in the number of

firms in the dominant industry reflect a proportional change in all buyer firms of all buying industries in a given commodity market. If there are fewer sellers than buyers then the relevant seller side information will be used. Like concentration, firm numbers are observed every five years for most of the commodities in the sample. The outlined interpolation and extropolation procedures used for concentration will also be implemented to replace missing values.

Price and Basis Risk

A common empirical measure of price risk is a measure of price variability. In this study a measure of price variability will also be utilized as a proxy for price risk. The appropriateness in using a price variability measure as a proxy is uncertain since price risk is not rigorously defined. Nonetheless the procedure adopted is within the bounds of the current literature. The only problem associated with price variability is choosing the appropriate measurement for this analysis. A measure of price variability that will be used in this analysis is the coefficient of variation. The virtue with this measurement is that it is independent of the commodity units because price variability is expressed as a percent of the mean price. Using average monthly prices observed in a given year, the mean and the variance are calculated for each commodity. It is assumed that hedgers and speculators are responsive to intraseasonal risk. For instance, stockholders are not so much concerned about next years prices as they are about prices in the next couple of months. Feedlot operators generally provide the feeding service within a year's time which necessitates concern regarding intraseaonsal prices. Speculators rarely hold a futures contract for more than a year suggesting their attention to short run

price risk. As such, it is felt that average monthly prices used to calculate an annual measure of the coefficient of variation is appropriate.

In the theory chapter the argument that price risk encourages hedging and speculative use of the futures market was put forth. Although this is the accepted view it may not hold over all ranges of price variability. For instance, in a market which is characterized by low price variability the benefits of a futures market may be very small. In this case hedgers may be willing to assume price risks, thus avoiding the transactions cost of trading futures. Also, it may take a certain risk level before the flexibility of liquid markets becomes advantageous relative to other forward exchange mechanisms. Speculators, too, may avoid markets with low price variability because the expectation of windfall gain may not exceed the cost of transaction. Hence, low levels of price variability may yield negative benefits to hedging and speculative participation.

Telser and Higinbotham [1977] point out that price variability can also increase exchange costs. This happens because exchange members who trade for their clients are liable in case of default. Since the risk of loss resulting from default is more likely to be greater in more price volatile markets, the cost of operating an exchange is higher in risky markets. This suggests that market activity should be inversely related to price variability as the cost of promoting the activity is an increasing function of price variability. In markets characterized by fairly stable prices this is not a great problem. However, as the degree of price volatility increases the risk of loss from default becomes more apparent. Thus, price variability has two effects on futures

market activity. First, it increases hedging and speculation activity because it provides a liquid means of dealing with price uncertainty. Second, it has the effect of increasing the cost of exchange operation.

Since it was suggested that at low levels of price variability the benefits of trader use may be nominal, the total effect of price variability on trading activity may be negative because of the cost effect. In other words increases in price volatility at these levels may increase the marginal cost of conducting trading on organized exchanges because of the increase in default risk. At higher levels it is expected that the effect of price variability on marginal benefits is heightened offsetting the cost effect. This leads to a positive response of market activity to increase in price variability. It follows that high levels of price variability will have a stronger impact on the benefit side. With regard to the model the implied relationship between market activity (e.g., hedging and speculation) and price variability is nonlinear. Specifically, it is hypothesized that this relationship is quadratic showing an inverse relationship at low levels of price variability and a positive level at higher levels (Figure 4.1). It could be argued that market activity should vanish in the absence of price uncertainty which implies that the adjustment function shown below emanates from the origin. However, the sample that will be used does not include such markets indicating that the quadratic adjustment hypothesis is appropriate for the data.

Basis variability would be a logical proxy to use for the conceptual variable, basis risk. There is a problem with the empirical use of basis variability, however. As an illustrative device consider the cash and futures activities of a stockholder. Assuming all costs are zero the

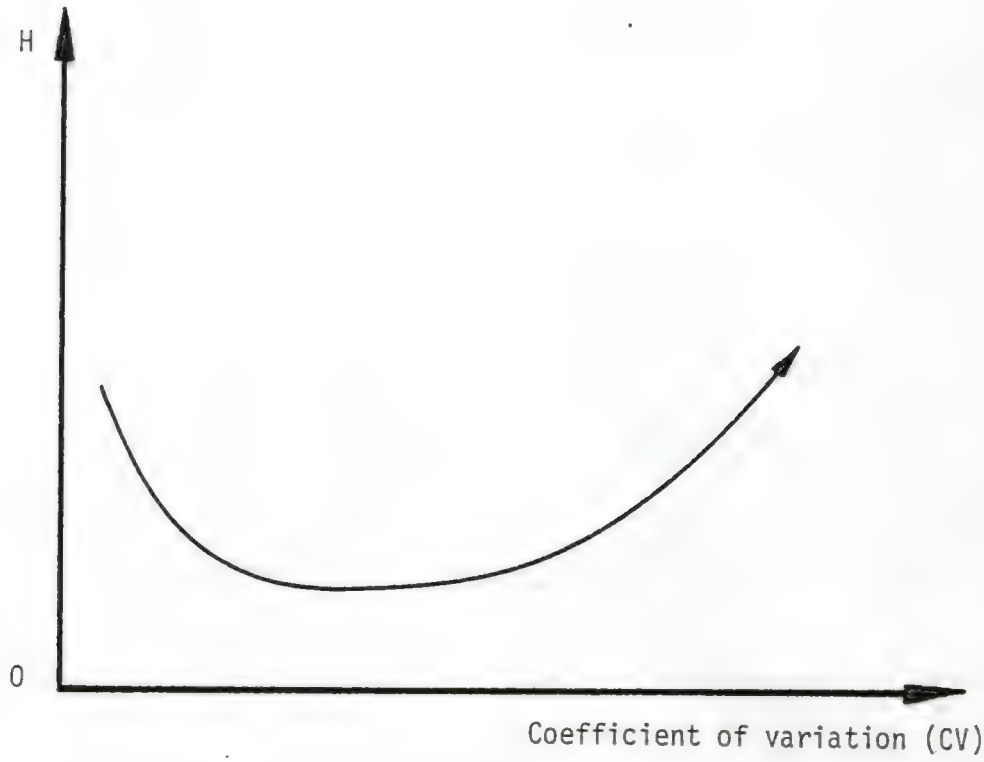


Figure 4.1--The effect of price variability on market activity

stockholder's expected returns on the stocks purchased in period t are:

$$(4.7) \quad E(R) = ([f_t - E(F_{t+1})] \cdot K + [E(p_{t+1}) - p_t]) \cdot X$$

where R = return,

f = futures price,

p = cash price,

X = stocks purchased,

K = proportion of stocks hedged.

In this example the stockholder acquires stocks in period t and sells an appropriate number of futures contracts. The stockholder plans to sell the stocks during period t+1. The variability of returns is given by

$$(4.8) \quad V(R) = (\sigma_p^2 + K^2\sigma_f^2 - 2K\rho_{pf}\sigma_p\sigma_f)X^2$$

where V(R) = return variance,

σ_p^2 = cash price variance,

σ_f^2 = futures price variance,

ρ_{pf} = cash-futures price correlation coefficient.

If it is assumed that $\sigma_p = \sigma_f$ then 4.8 simplifies to the following:

$$(4.9) \quad V(R) = X^2 \cdot \sigma_p^2((1 + K) - 2K\rho_{pf})$$

In this case the individual can control risk exposure through control of size (i.e., the choice of X) and the extent of the hedge (i.e., K). Now consider the variability of the basis:

$$(4.10) \quad V(b) = \sigma_p^2 + \sigma_f^2 - 2\rho_{pf}\sigma_p\sigma_f$$

where V(b) = basis variability.

If k=1 then 4.8 is proportional to basis variability by a factor of X^2.

If $k \neq 1$, then the relationship between V(R) and V(b) is more obscure [Ward and Schimkat, 1979]. Consequently basis variability may not reflect the risks of individual decisions to hedge because the X^2 and K are individually determined, whereas 4.10 is market determined.

An alternative to using basis variability as a proxy for basis risk is the correlation coefficient between the cash and futures prices. From 4.10 it is apparent that ρ_{pf} is inversely related to the variance. As such one would expect that a high correlation coefficient enhances hedging activities because basis risk is reduced. The correlation coefficient is calculated from average monthly cash prices and the mid-month closing futures price of the nearby futures contract. A correlation coefficient is calculated for each year in the sample for each of the included markets in the investigation. Note that V(b) is not related to the parameter K whereas the V(R) is dependent on K.

Maturation

In chapter 3 it was argued that the evolving futures market experiences a growth period in the early stages of development as hedgers and speculators become more knowledgeable with regard to market use. An obvious proxy variable for maturation is the age of a market. Information regarding market age is readily available. Market age ranges from 9 to over 120 in 1978 for the markets included in the sample. Five markets were developed during the sample period which suggests the effects of maturation are present in the data set. The effect of age on hedging should be nonlinear given the maturation argument. A plausible relationship between hedging and age is characterized by the logistic functional form (Figure 4.2). The effect of age is great when the market is young but the effect approaches zero in an older more mature

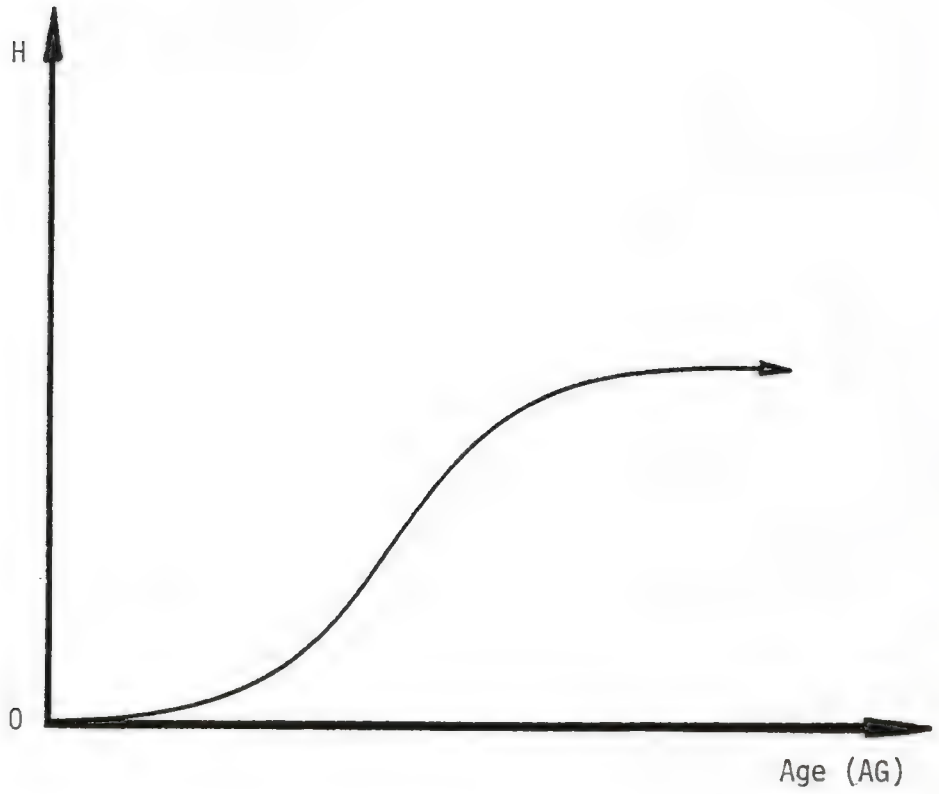


Figure 4.2--The effect of age on hedging

market. The same adjustment process between age and speculation is expected. However, Working [1962] has suggested that young markets may require excess speculation to attract necessary hedging. This effect, if it exists, would cloud the hypothesized relationship.

Perishability

The degree of commodity perishability was argued to be influential on net benefits through its impact on hedging, speculation and volume. Unfortunately, there are no precise empirical measures of perishability. The commodities included in the sample vary with regard to perishability ranging from very storable to semi-perishable in the case of fresh eggs. A simple means of handling this problem is to classify the commodities as storable or nonstorable. This classification can easily be adapted to an econometric framework with the use of a dummy variable. A simple classification, like the one proposed, avoids the arbitrary process of defining a more refined classification scheme which would include intermediate degrees of perishability. In addition, it is believed that the simple scheme, which clearly distinguishes the storables from the nonstorables, is "rich" enough to show the effects of perishability. The commodities included in the sample and their corresponding perishability classification are listed in Table 4.1.

Government Effects

Several of the commodities included in the sample are included in government price support programs. Whenever the commodity price drops to the support level the government intervenes to forestall further price declines. It was argued that as the commodity price nears the support level short hedging activities are diminished. An empirical measure that

Table 4.1--Classification of commodities by degree of perishability

Storable	Nonstorable
Wheat	Live Hogs
Corn	Live Cattle
Oats	Feeder Cattle
Soybean	Fresh Eggs
Soybean Oil	
Soybean Meal	
Potatoes	
Frozen Pork Bellies	
FCOJ	
Cotton	

will capture this effect is defined as follows:

(4.11) LN = (Loan Rate)/(Commodity Price)

This ratio ranges between 0 and 1. As the ratio approaches one the effect of the price support program on hedging activities becomes more acute since the cash price is near the support level implying minimal risk of further price decline. Loan rates are subject to change from year to year. Consequently, annual observations are made on LN for each commodity market. The commodity price used is the mean price calculated from 12 monthly observations during the year in which the respective loan rate is observed. The effect of LN on hedging is depicted in the figure below (Figure 4.3). At low levels LN has no effect on hedging, but as LN approaches one, hedging activity is severely affected.

Opportunity Cost and Intermarket Spreading

In the theory chapter it was argued that holding futures contracts was one of many possible investment opportunities facing speculators. Consequently, speculative involvement in the futures market will be

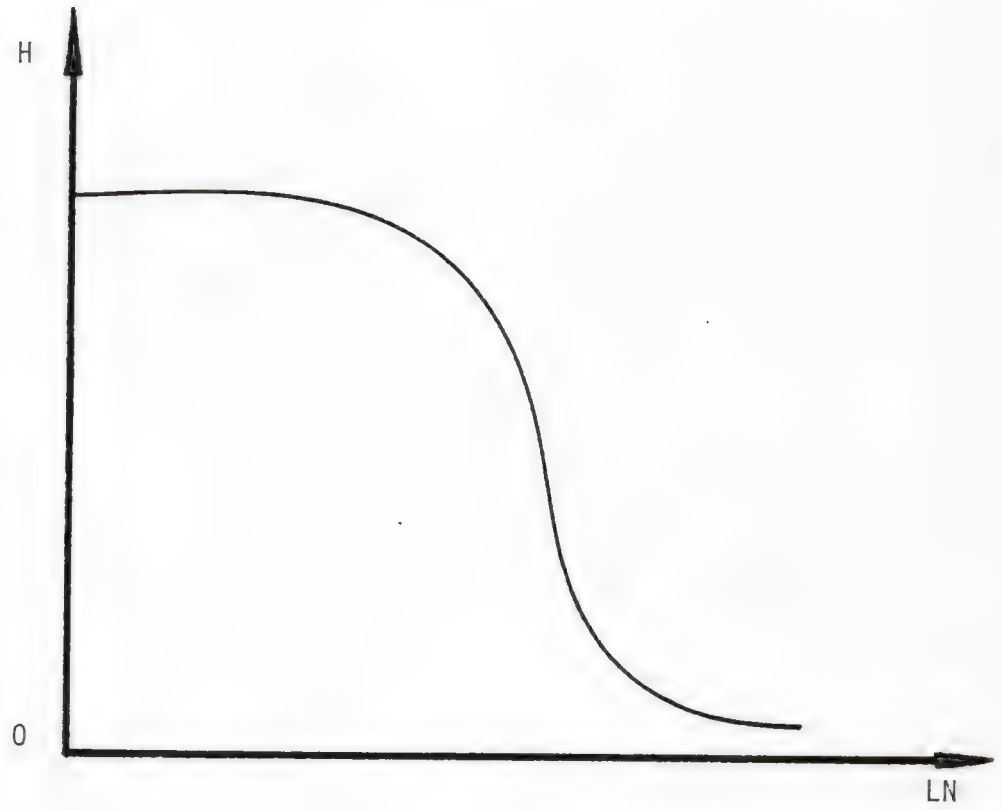


Figure 4.3--Theoretical effect of government price supports on hedging

sensitive to the expected rates of return that could be earned elsewhere. One possible investment opportunity is the stocks of the various utility companies traded on the New York Stock Exchange. In the past these companies have paid competitive dividends to stockholders. The yield in owning stock in a utility is relatively high with respect to other industrial groupings. Yields are computed by dividing dividends earned by the value of the stock owned. If it is assumed that the yield observed in year t is the market expectation of the expected rate of return for year t+1, then current yield values can be used as a proxy for the speculative opportunity cost of capital. The actual yield value that will be used is an annual average yield of the 40 utility stocks used in the computation of the Dow Jones index of utility stocks. There is no special reason why the yield on utility stocks was chosen as a proxy for the opportunity cost of futures market speculation other than the fact that the data were very accessible. Return rates on comparable investment opportunities will be highly correlated with one another over time and, hence, the use of utilities should not bias the results. As stated earlier, speculative capital should flow from the futures institutions when alternative less risky investment opportunities improve.

Intermarket spreading was suggested as an important variable affecting speculative activity. Unfortunately, detailed data on intermarket spreading activities are limited. An idea of the extent of spreading between markets can be obtained by looking at intermarket price relationships. Recall that hedgers were argued to be responsive to the correlation between the cash and futures price. In the same vein speculators will likely be responsive to price spreads and the degree

of correlation of prices across markets. Some speculators may prefer to predict future price relationships rather than predict absolute prices for several reasons. Often a spread position is entitled to lower commissions and margin requirements. In addition the risk of a large loss is lessened because of the high correlation between the intermarket prices.

A proxy variable developed to account for the intermarket spreading opportunities uses the correlation coefficient statistic constructed from the price series of two markets over the sample period. To illustrate the precise nature of this variable consider n markets with T years of monthly observations on the price of each market. For each market n-1 correlation coefficients can be calculated. The maximum correlation coefficient among the n-1 calculated statistics for each market is the proxy for intermarket spreading opportunities. Alternatively, this is written as follows:

$$(4.11) \quad SV_i = MAX_i \ (\sigma_{ij}/(\sigma_i^2 \cdot \sigma_j^2)) \qquad i = 1, n \quad j = 1, n \quad i \neq j$$

where SV_i = value of the intermarket spreading variable for market i,

σ_{ij} = the covariance between the price series of market i and the price series of market j,

σ_i^2 = the variance of price in market i,

σ_j^2 = the variance of price in market j.

Each market will have a corresponding time invariant value of SV. A high value of SV suggests ample spreading opportunities, whereas a low SV suggests spreads are more risky. There are some problems with this procedure, however. One such problem is the number of markets, n, which are used to construct SV is limited to the markets included in the sample.

Within this sample a market with low spreading opportunities may have excellent opportunities if more markets were included. However, a priori information regarding the spreading opportunities of the included markets is consistent with the values of SV that were calculated. Since SV is indicative of the spreading potential of a market, it is used despite the presence of such problems.

Technological Change and Scale Effects

Over the last two decades tremendous advances have been made in computer technology and the communications industry. These factors play an important role in the operation of a futures market especially in the processing of trades and the dissemination of information. Since these changes can affect the cost side of futures market activity, the futures market net benefit function can be expected to respond. A time trend variable will be used as a proxy for technological change. Time trend variables are often used in empirical work because of the difficulty involved in quantifying technological change. To construct the time trend variable, TT, a value of one is assigned for the year 1961, two for the year 1962, and so on. This variable is similar to the age variable, but it has an important distinguishing characteristic. Cross-sectionally, the observations on the time trend variable are invariant, whereas the age variable can vary contemporaneously because markets have differing ages. The time trend variable is constructed to capture those events occurring between 1961 and 1978 which affect all markets similarly.

The scale effect of an exchange on one of its markets will be handled in two ways. There are 16 futures markets included in the sample, but these markets conduct trading on the floor of only six exchanges. Differences in the futures trading activity on the six exchanges are

quite apparent. It is believed that scale economies are present in exchange operation. As the number of markets increase the fixed cost of exchange operation can be spread over more market units. Defining NP as the number of markets traded on the floor of an exchange, it is hypothesized that the average cost of providing a given level of futures market activity is a declining function of NP. Hence, it is argued that NP increases net benefits through its positive partial effect on volume. This positive partial effect is reinforced by the fact that many markets traded on a single floor may enhance liquidity for one another because there is probably more information of better quality that is easily accessed.

The number of markets traded on the exchange floor may not tell the complete story of scale effects. Exchanges with only a few markets may have an inordinate amount of transactions (volume) that is processed within a year's time. Alternatively, for a given number of markets the fixed cost of exchange operation can be spread over more transactions as volume increases. Thus, exchange volume would seem appropriate as a scale proxy as well. However, exchange volume is some function of endogenous variables, since exchange volume in a given year is the sum of the transactions that occur on each market. As an alternative the six exchanges will be ranked according to volume in each of the 18 years covered by the sample period. A ranking of one suggests that the exchange had the highest level of activity in terms of volume in the year in which the one is observed. Define ER as the exchange rank variable. It follows that volume is an inverse function of ER.

Choice of Functional Form

In the theory chapter the parameter signs of the conceptual model given by equation 3.6 were hypothesized. In order to test these hypotheses 3.6 must be adapted for empirical use. An important aspect of this process is the choice of functional form. Unfortunately, the functional form is not implied by the theory; however, this turns out to be more helpful than harmful. Since there may be a number of functional forms that would satisfy the assumptions of the net benefit function, there is more latitude in selecting the functional form to be used. The goal is to specify the functional form of the system of equations such that these equations are readily adapted to econometric analysis. However, the functional form of these equations implies a corresponding net benefit function since these equations are the first order conditions. To ensure theoretical plausibility of the empirical analysis, only those functions that satisfy the assumptions of the net benefit model will be considered.

A Quadratic Net Benefit Function

In most econometric models the estimable equations are intrinsically linear. Although there are nonlinear estimation techniques available, the simplicity of linear techniques is preferred. Consequently, the equations will be specified so that this criterion is met facilitating the subsequent econometric analysis. The satisfaction of this criterion implies a net benefit function of a certain form. Specifically, the form implied is given by the class of quadratic functions. A quadratic net benefit function is expressed algebraically as follows:

$$(4.12) \quad N = \sum_{i=0}^{n} \sum_{j=0}^{n} \alpha_{ij} X_i X_j$$

where N = net benefits,

X_i = the model variables $\quad i = 1, \ldots, n,$

α_{ij} = the model parameters $\quad i = 0, \ldots, n,$

$\quad j = 0, \ldots, n,$

$X_0 = 1.$

It is apparent that the first order conditions of 4.12 with respect to the X_i are linear in form. Writing the first order conditions explicitly yields:

$$(4.13) \quad \frac{\partial N}{\partial X_i} = \sum_{j=0}^{n} \alpha_{ij} X_j = 0 \qquad i = 1, \ldots, 0.$$

The net benefit model has three endogenous variables--hedging, speculation, and volume. For the moment define the endogenous variables as X_1, X_2, and X_3, respectively. In this case 4.13 reduces to three equations since the other X_i ($i \neq 1, 2, 3$) are exogenous variables and are determined outside the system. The linear first order conditions are not so restrictive as it may seem. Nonlinearities can be built into the system by transforming the X_i, yet leaving the intrinsically linear property intact. This is gratifying because earlier it was suggested that the relationship between age and hedging was nonlinear.

In the theory chapter it was assumed that the net benefit function was strictly concave. The quadratic function given by 4.12 satisfies this assumption if the following properties hold [Chiang, 1974, p. 328]:

$$(4.14) \quad \alpha_{11} < 0,$$

$$(4.15) \quad \alpha_{11}\alpha_{22} - \alpha_{21}\alpha_{12} > 0,$$

$$(4.16) \quad \alpha_{11}(\alpha_{22}\alpha_{23} - \alpha_{32}\alpha_{23}) - \alpha_{12}(\alpha_{21}\alpha_{33} - \alpha_{31}\alpha_{23}) + \alpha_{13}(\alpha_{21}\alpha_{32} - \alpha_{31}\alpha_{22}) < 0.$$

Although it would be desirable to empirically verify these conditions, the estimation procedure employed does not permit the determination of the above parameters. Further, direct estimation of 4.12 is impossible because N is unknown. In the commonly used estimation techniques the parameters on the endogenous variables are normalized, where they appear as dependent variables according to theory. As such, the parameters of the model are some function of the above parameters and the other α_{ij}. To see this 4.12 is rewritten as follows:

$$(4.17) \quad X_1 = (\Sigma_j \alpha_{1j} X_j)/\alpha_{11} \qquad j = 0, 2, 3, \ldots, n;$$

$$(4.18) \quad X_2 = (\Sigma_j \alpha_{2j} X_j)/\alpha_{22} \qquad j = 0, 1, 3, \ldots, n;$$

$$(4.19) \quad X_3 = (\Sigma_j \alpha_{3j} X_j)/\alpha_{33} \qquad j = 0, 1, 2, 4, \ldots, n.$$

It is apparent from the above system that there are $3 \cdot n$ structural parameters to be estimated and $3 \cdot (n + 1)$ unknown parameters. Consequently, a unique solution to the parameter vector does not exist which impedes the empirical verification of second order conditions. However, the aim of this research is not directed at the determination of the parameters of the net benefit function. Rather, the main interest is to learn about the effects of the exogenous variables on hedging, speculation, and volume as well as the relationship among the endogenous variables.

The Logistic Function

In several instances it has been argued that the relationship between the exogenous variables and the endogenous is nonlinear. A functional form that allows for nonlinearities yet is intrinsically linear in the parameters is the logistic function. The logistic function is expressed mathematically as follows:

$$(4.20) \quad y_1 = \frac{1}{1+\exp(\alpha_0+\alpha_1 y_2)}$$

A closer examination of 4.20 by taking the derivatives and presenting the asymptotic properties is more revealing. Taking the derivative of y_1 with respect to y_2 yields

$$(4.21) \quad \frac{dy_1}{dy_2} = -\alpha_1(1-y_1)(y_1) \gtreqless 0 \text{ as } \alpha_1 \lesseqgtr 0.$$

The second derivative is given by

$$(4.22) \quad \frac{d^2y_1}{dy_2^2} = \alpha_1^2(1-2y_1)(1-y_1)y_1 \gtreqless 0.$$

The logistic function also has the property of approaching some asymptotic limit. The asymptotic properties are listed below:

$$\lim_{y_2 \to 0} y_1 = \frac{1}{1+\exp(\alpha_0)},$$

$$\lim_{y_2 \to \infty} y_1 = 1 \text{ if } \alpha_1 < 0,$$

$$\lim_{y_2 \to \infty} y_1 = 0 \text{ if } \alpha_1 > 0.$$

Using the above information the logistic function is illustrated in Figure 4.4.

The nonlinear relationships which are captured by the logistic functional form makes its use in the subsequent econometric analysis very appealing. It is very likely that over wide ranges of values of the exogenous variable there will be no consequent affect on the endogenous variables. This may explain the stability or instability of some futures markets. Consider the loan rate (LN) variable which was defined as the support price divided by the mean commodity price observed in market i in period t. If the support price is a small fraction of the commodity price it is very unlikely that goverment support policy will affect

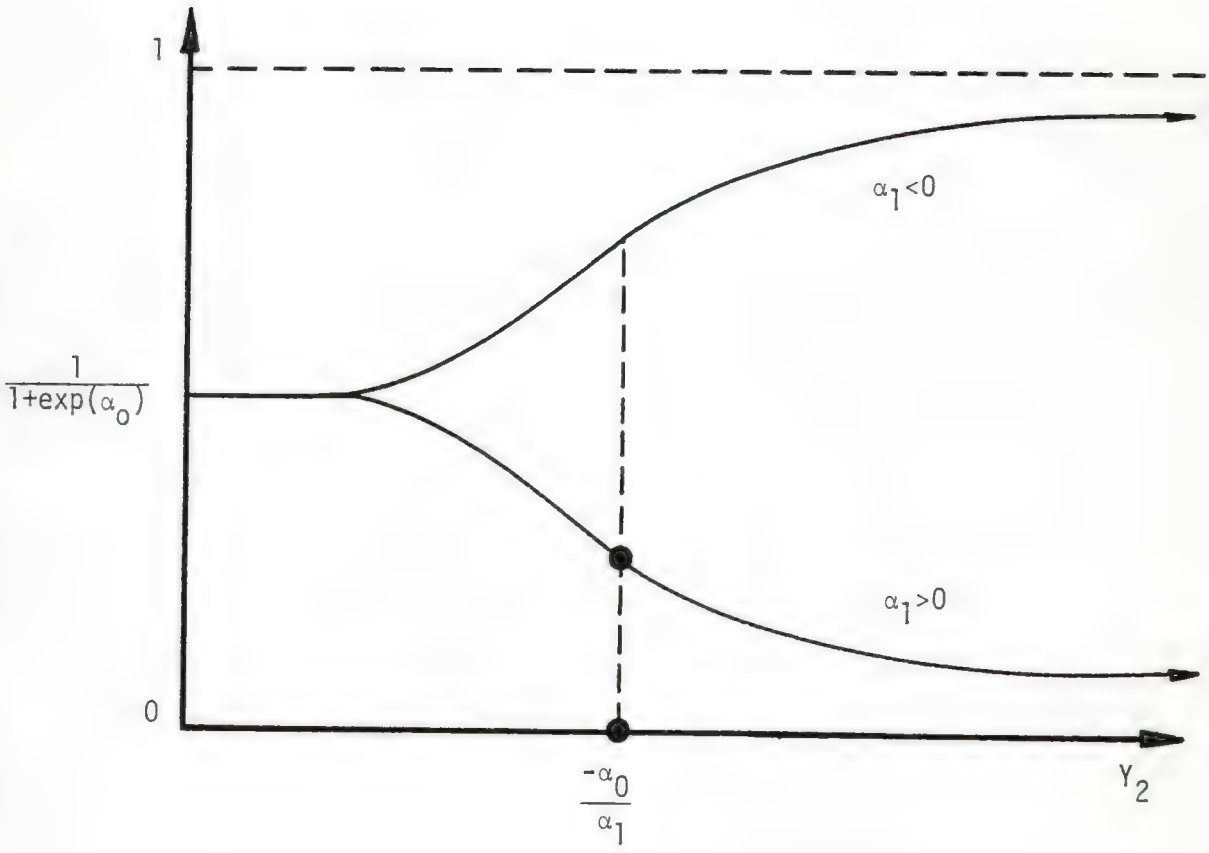


Figure 4.4--Theoretical graph of the logistic function

hedging activities in futures market i. However, at higher levels of LN the effect of the price support policy should be pronounced. As the loan rate variable approaches one only a minimal quantity of hedging activity, presumably long hedging, is expected.

It was previously argued that the age variable may be related to the hedging variable by a logistic functional relationship. Use of the logistic functional form in an econometric analysis would capture this effect. In the case of the opportunity cost of capital as measured by the yield on utility stocks, low yield rates are not expected to draw speculative dollars from futures markets because the transactions cost incurred may outweigh the expected gain. As such, changes in the yield at such levels will not encourage speculative response. At higher yields a response is expected, however. It was also argued that concentration had a quadratic effect on hedging. This is readily adapted to the logistic functional form framework as illustrated in Figure 4.5.

The function reaches at maximum when CN is equal to the ratio of $-\alpha_k$ to $2\alpha_{k+1}$. At high levels of concentration the concentration effects are strictly negative as hedging activities are significantly restricted. Most if not all of the environmental forces affecting futures market behavior are expected to cause nonlinear adjustments in hedging, speculation and volume. Hence, the logistic functional form will be adopted in the empirical specification of equation 3.6 since it is consistent with the theoretical model and can be easily adapted to econometric estimation procedures.

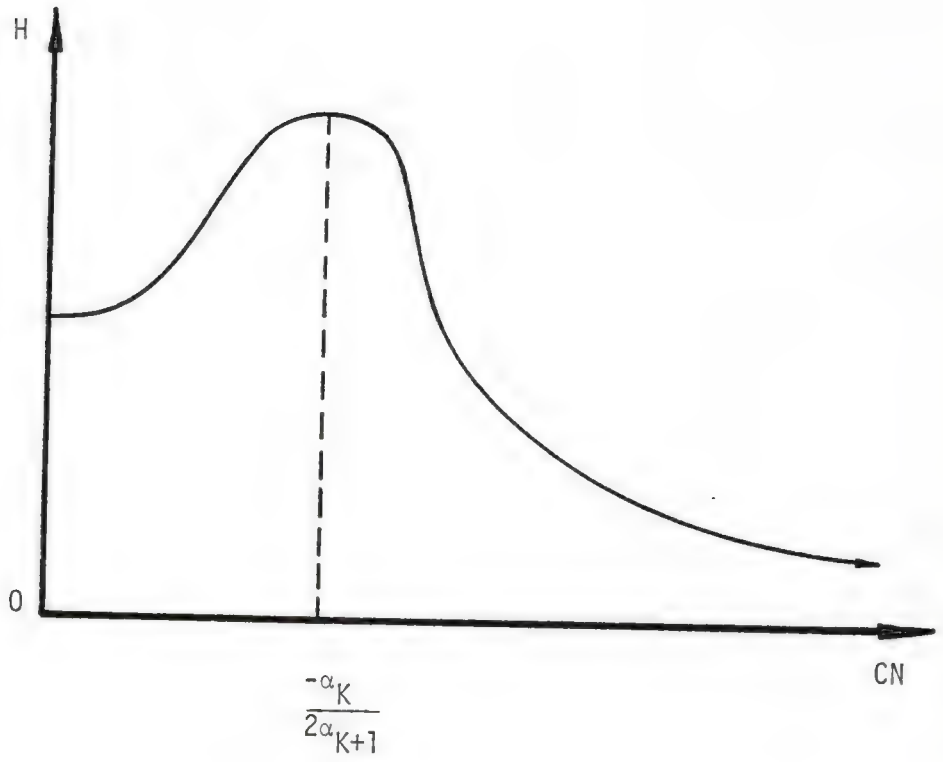


Figure 4.5--Theoretical effect of concentration on hedging

Mathematical Trading Model

Using the empirical variable definitions and the logistic functional form, an explicit representation of 3.6 is now given. The endogenous variables are related using the β parameters while the exogenous effects are shown with Γ.

$$(4.23)\quad H_{it} = \beta_{12}S_{it} + \beta_{13}V_{it} + \Gamma_{10} + \Gamma_{11}CN_{it} + \Gamma_{12}CN_{it}^2 + \Gamma_{13}FN_{it} + \Gamma_{14}CC_{it} + \Gamma_{15}CV_{it} + \Gamma_{16}CV_{it}^2 + \Gamma_{17}LN_{it} + \Gamma_{18}PE_{it} + \Gamma_{19}AG_{it}$$

$$(4.24)\quad S_{it} = \beta_{21}H_{it} + \beta_{23}V_{it} + \Gamma_{20} + \Gamma_{25}CV_{it} + \Gamma_{26}CV_{it}^2 + \Gamma_{28}PE_{it} + \Gamma_{29}AG_{it} + \Gamma_{2,10}UY_{it} + \Gamma_{2,11}SV_{it}$$

$$(4.25)\quad V_{it} = \beta_{31}H_{it} + \beta_{32}S_{it} + \Gamma_{30} + \Gamma_{38}PE_{it} + \Gamma_{3,11}SV_{it} + \Gamma_{3,12}NP_{it} + \Gamma_{3,13}ER_{it} + \Gamma_{3,14}TT_{it}$$

where $H_{it} = \log\left(\frac{1}{H^*_{it}} - 1\right)$,

H^*_{it} = hedging expressed as percent of total supply in market i during period t,

$S_{it} = \log\left(\frac{1}{S^*_{it}} - 1\right)$,

S^*_{it} = speculation expressed as percent of total supply,

$V_{it} = \log\left(\frac{1}{V^*} - 1\right)$,

V^*_{it} = average daily volume expressed as percent of total supply,

CN_{it} = concentration ratio associated with market i in period t,

FN_{it} = firm numbers associated with market i in period t,

CC_{it} = correlation coefficient between the cash and futures price associated with market in period t,

CV_{it} = coefficient of variation of the cash prices associated with market i in period t,

AG_{it} = age of market i in period t,

LN_{it} = the loan rate expressed in percent associated with market i in period t,

PE_{it} = the degree of perishability assigned to commodity i (i.e., PE_i is a dummy variable with PE_i=1 if commodity is storable and PE_i=0 otherwise),

UY_{it} = the yield expressed in percent on the utility stocks in year t,

SV_{it} = the spreading variable associated with market i showing the price correlation with market j,

NP_{it} = the number of markets on the floor of the exchange where trade occurs in market i during period t,

ER_{it} = the rank from 1 to 6 of the exchange where trade occurs in market i during period t,

TT_{it} = time trend variable ranging from 1 for 1961 to 18 for 1978.

The data and the corresponding sources are given in Appendices B and C.

Before proceeding with the econometric analysis, a table presenting the hypothesized sign for each parameter of 4.23, 4.24, and 4.25 is given (Table 4.2). The hypotheses follow directly from the partial effects of the conceptual model. Consider the structural parameter associated with firm numbers (FN) in 4.23. The parameter measures the effect of FN_{it} on H_{it} (i.e., $\frac{\partial H_{it}}{\partial FN_{it}}$), ceteris paribus. Since the effect on H^*_{it} is of primary interest it follows:

$$(4.26)\quad \frac{\partial H^*_{it}}{\partial FN_{it}} = \frac{\partial H_{it}}{\partial FN_{it}} \cdot H^*_{it}(1 - H^*_{it}) = -\Gamma_{13} \cdot H^*_{it}(1 - H^*_{it})$$

Table 4.2--Sign hypotheses of the Γ_{ij}

Variable[a]	Description	Parameter and sign hypothesis
CN	Concentration	$\Gamma_{11} < 0$
CN^2	Concentration	$\Gamma_{12} > 0$
FN	Firm numbers	$\Gamma_{13} < 0$
CC	Futures/Cash Correlation	$\Gamma_{14} < 0$
CV	Price risk	$\Gamma_{15} < 0$, $\Gamma_{25} < 0$
CV^2	Price risk	$\Gamma_{16} > 0$ $\Gamma_{26} > 0$
LN	Loan level	$\Gamma_{17} > 0$
AG	Maturity	$\Gamma_{18} < 0$ $\Gamma_{28} < 0$
PE	Perishability	$\Gamma_{19} < 0$ $\Gamma_{29} < 0$, $\Gamma_{39} < 0$
UY	Interest yield	$\Gamma_{210} > 0$
SV	Spreading	$\Gamma_{211} < 0$, $\Gamma_{311} < 0$
NP	Number of pits	$\Gamma_{312} < 0$
ER	Exchange ranking	$\Gamma_{313} > 0$
TT	Time trend	$\Gamma_{314} < 0$

[a]See Appendix C for data.

Since $H^*_{it}(1 - H^*_{it})$ will always be positive the partial $\frac{\partial H^*_{it}}{\partial FN_{it}}$ will have the opposite sign of $\frac{\partial H_{it}}{\partial FN_{it}}$. Looking at the hypothesized parameter sign in Table 4.2 it is apparent that the logistic functional form has reversed the expected parameter signs. For example, an increase in firm numbers is expected to increase hedging activity. This implies that Γ_{13} is negative rather than positive.

Endogenous Variable Interrelationships

The sign hypotheses on the parameters associated with the endogenous variables do not appear in Table 4.2. In the conceptual model little was said concerning the interrelationships of the endogenous variables, although the interdependencies have been alluded to throughout. For instance, developing as well as existing markets need sufficient speculation to ensure that hedging costs are minimal. Otherwise, hedgers may have to make price concessions to expedite trades if there are an insufficient number of traders present. Speculators, on the other hand, require hedging use to ensure that the futures price is responding to market fundamentals (i.e., to commodity supply and demand information). In these cases there is an implied two-directional causal linkage between hedging and speculation. It is assumed that this causal linkage is indirect as both variables are related via the interaction with market liquidity.

Speculative trade on futures markets is generally credited with enhancing the liquidity of a market. Using Telser's model of liquidity as a theoretical construct, it was observed that the larger the number of participants in the market place, the smaller the distribution of market clearing prices. Recalling that Telser defines market liquidity

as being an inverse function of this distribution, then it follows that increased speculative participation increases market liquidity. In the present model as was the case in Telser's model the volume of trade is used as a conceptual measure of the distribution of market clearing prices since this distribution is not observable in practice. It was argued that volume is a manifestation of the degree of market liquidity because volume suggests homogeneity of bids and offers and/or an increased level of bids and offers (see Chapter 2). Thus an increase in speculative trade increases volume because it implies a positive effect on market liquidity. Since hedgers benefit from the low transactions costs of liquid markets, it follows that speculative trade is beneficial to hedging activities, not directly, but through its impact on liquidity.

Hedging can also enhance liquidity despite the fact that it is not typically recognized as such. Hedging activities are continually arbitraging the cash and futures markets. A hedged cash position is a form of arbitrage, in fact. If the basis becomes too large or small profits can be earned with a simultaneous position in both markets. Hedging activities ensure that the futures price adheres to the fundamental supply and demand conditions of the underlying cash market.

It is assumed that futures markets with great hedger participation have higher quality price information as the discovery process better reflects market fundamentals. In such markets the homogeneity of bids and offers is likely to be increased because arbitrage activities keeps the futures price in alignment with the cash price. From the theory of liquidity it follows that increased hedging participation enhances market liquidity. Alternatively, hedging has a positive effect on volume. In the literature it is argued that speculators are attracted to markets with considerable hedging activity because the futures price closely reflects

fundamentals. However, it is apparent that this effect is indirect in that hedging increases volume (i.e., liquidity) which accounts for the enhanced quality of the discovered price.

There is also a technical relationship between the open interest variables and volume. In order to obtain an open commitment a trade must transpire. It is readily apparent that a change in open interest of X contracts from one day to the next requires at least X contracts of volume. Hence, aside from the positive effect of hedging and speculation on volume resulting from liquidity enhancement there is a technical relationship that is also assumed to be positive.

With the above arguments hypotheses regarding the β_{ij} in 4.23, 4.24, and 4.25 can be made. First note that the relationship between $\frac{\partial H_{it}}{\partial S_{it}}$ and $\frac{\partial H^*_{it}}{\partial S^*_{it}}$ is as follows:

$$(4.27) \quad \frac{\partial H^*_{it}}{\partial S^*_{it}} = \frac{\partial H_{it}}{\partial S_{it}} \cdot \left(\frac{H^*_{it}(1-H^*_{it})}{S^*_{it}(1-S^*_{it})}\right)$$

The term $\frac{\partial H_{it}}{\partial S_{it}}$ corresponds to the parameter β_{12} in 4.23. Since the last value on the right is nonnegative, the sign of $\frac{\partial H^*_{it}}{\partial S^*_{it}}$ depends on β_{12}. Likewise, the sign of $\frac{\partial H^*_{it}}{\partial V^*_{it}}$ depends on β_{13}; the sign of $\frac{\partial S^*_{it}}{\partial N^*_{it}}$ depends on β_{21}; the sign of $\frac{\partial S^*_{it}}{\partial V^*_{it}}$ depends on β_{23}; etc. The arguments on the nature of the causality between hedging, speculation, and volume suggest that $\beta_{12} = \beta_{21} = 0$ or the effect of hedging on speculation and speculation on hedging is indirect. The parameters β_{13} and β_{23} are hypothesized to be positive because they represent the effect of liquidity on hedging and speculative behavior, respectively. Finally, β_{31} and β_{32} are also positive because of the hedging and speculative effect on liquidity. This hypothesis is further reinforced by the technical relationship between open interest and volume.

In the theory chapter it was argued that the effect of a change in an exogenous variable on an endogenous variable could be decomposed. A partial effect was defined as the change in an endogenous variable resulting from a change in an exogenous variable holding the other endogenous variables fixed. For instance, a change in LN_{it} results in the following partial effect on H^*_{it}:

$$(4.28) \quad \frac{\partial H^*_{it}}{\partial LN_{it}} = - \Gamma_{17}(H^*_{it})(1-H^*_{it})$$

The goal of the econometric analysis is to obtain estimates of parameters such as Γ_{17} so that the hypotheses, which are summarized in Table 4.2, can be tested. In addition, it is desirable to say something about the new equilibrium when the system has been shocked by a change in the exogenous variables. The total effects which were derived in Chapter 3 equation 3.14 measure the changes in equilibria given an exogenous shock. These effects can be determined by solving for equations 4.23, 4.24, and 4.25 in terms of hedging, speculation, and volume. The nature of the total effect will depend on the sign and the magnitude of the β_{ij}'s as well as the sign and magnitude of the respective partial effect. In the following chapter the econometric analysis will be performed so that estimates of these parameters can be obtained. This will provide a basis for the empirical discussion of the partial and total effects.

Summary

A mathematical specification of the futures trading model was setforth and all variables were defined. Allocation schemes for dealing with nonreported trader commitments were developed. Alternative structural equations were discussed with primary emphasis devoted to the

logistic specification. The hedging, speculation, and volume activities were each expressed in terms of potential trading.

Econometric procedures and empirical results will be dealt with in the next chapter.

CHAPTER 5

AN ECONOMETRIC ANALYSIS OF FUTURES TRADING

In this chapter the econometric model will be developed from the system of equations given by 4.23, 4.24, and 4.25. There are several econometric problems present which makes the search for an appropriate estimator arduous. Estimation questions that will be discussed include the identification problem; problems associated with pooling cross-sectional and time series data; estimation of an unbalanced model where the cross-sections have an unequal number of observations in time and contemporaneous correlation in the disturbances. Following this discussion the model estimator will be presented. The estimator closely resembles the three-stage least squares estimator but with an important modification. This modification arises from the assumptions made concerning cross-sectional differences in futures market behavior. In the last section a broad overview of the statistical results will be given. In the subsequent chapter the results will be investigated at greater depth.

The Econometric Model

The model that is to be estimated is given by the following three-equation system:

$$(5.1)\quad H_{it} = \beta_{12}S_{it} + \beta_{13}V_{it} + \Gamma_{10} + \Gamma_{11}CN_{it} + \Gamma_{12}CN_{it}^2 + \Gamma_{13}FN_{it} + \Gamma_{14}CC_{it} + \Gamma_{15}CV_{it} + \Gamma_{16}CV_{it}^2 + \Gamma_{17}LN_{it} + \Gamma_{18}PE_{it} + \Gamma_{19}AG_{it} + \mu_{it}^1$$

$$(5.2)\quad S_{it} = \beta_{21}H_{it} + \beta_{23}V_{it} + \Gamma_{20} + \Gamma_{25}CV_{it} + \Gamma_{26}CV_{it}^2 + \Gamma_{28}PE_{it} + \Gamma_{29}AG_{it} + \Gamma_{2,10}UY_{it} + \Gamma_{2,11}SV_{it} + \mu_{it}^2$$

$$(5.3)\quad V_{it} = \beta_{31}H_{it} + \beta_{32}S_{it} + \Gamma_{30} + \Gamma_{38}PE_{it} + \Gamma_{3,11}SV_{it} + \Gamma_{3,12}NP_{it} + \Gamma_{3,13}ER_{it} + \Gamma_{3,14}TT_{it} + \mu_{it}^3$$

where μ_{it}^j = the disturbance term,

$i = 1, 2, \ldots, 16,$

$t = 1, 2, \ldots, T_i,$

$j = 1, 2, 3.$

Since it is impossible to explain all the variation in the endogenous variables, the disturbance term, μ_{it}^j, is introduced to capture the unexplained variation. It is assumed that the disturbance is random with mean zero. Further, it is assumed that the μ_{it}^j are serially independent and independent of the exogenous variables. Additional assumptions regarding the variance-covariance matrix of the μ_{it}^j are developed in the discussion which follows shortly.

Identification

In the estimation of parameters in a simultaneous equation system the problem of identification must be addressed. A situation might arise where the parameters of one or more equations can not be estimated because they are underidentified. This happens because the unidentified equation can not be distinguished from a linear combination of all equations. Consequently, the estimated parameters of the unidentified equation are not the structural parameters for that equation, but they are some "mixture" of the parameters of all the equations [Maddala, 1977]. To check the identification of the above model it is customary to see

whether the equations satisfy the rank and order conditions, which are a necessary and sufficient condition for identification. Looking at equations 5.1, 5.2, and 5.3 it is apparent that each of the equations are exactly identified by the rank condition. However, the order condition for identification suggests that each of the three equations are over-identified. Over-identification implies that Ordinary Least Squares (OLS) estimation of the reduced form equations will yield multiple solutions. Consequently, the OLS method does not give consistent parameter estimates because the residuals and the endogenous regressors will be correlated. If the equations were exactly identified by the order condition, consistent estimates of the reduced form parameters would be obtained using OLS. With these estimates consistent estimates of the structural parameters can be uniquely solved [Maddala, 1977]. Since consistency is a desired property, an alternative estimator is sought given the over-identification problem.

Pooling Cross-Sectional and Time Series Data

Often in pooling problems it is difficult if not impossible to capture all of the important cross-sectional effects. In other words there may be specific factors associated with each cross-section that help explain the endogenous variables but are unavoidably excluded from the model. This specific ignorance is information that is confounded within the disturbance term. Consider the disturbance term of the jth equation for a particular observation:

$$(5.4) \quad \mu^j_{it} = \nu^j_{it} + \varepsilon^j_i$$

where ν^j_{it} = the part of the disturbance, μ^j_{it}. that results from general ignorance,

ε_i^j = the part of the disturbance that results from the specific cross-sectional ignorance.

It is assumed that:

$$E(\nu_{it}^j) = E(\varepsilon_i^j) = E(\nu_{it}^j, \varepsilon_i^j) = 0$$

$$E(\nu_{it}^j, \nu_{i't'}^j) = \begin{cases} \sigma_\nu^2 & i=i',\ t=t',\ j=j' \\ 0 & \text{otherwise} \end{cases}$$

$$E(\varepsilon_i^j\ \varepsilon_{i'}^{j'}) = \begin{cases} \sigma_\varepsilon^2 (i=i',\ j=j') \\ 0\ (\text{otherwise}) \end{cases}$$

In many applications the disturbance associated with the cross-sectional component enters the model as an intercept. Thus, the intercept is assumed to be random with the above properties. However, this specification is arbitrary in that the intercept could be a constant with the cross-sectional effect entering solely through the disturbance term [Judge et al., 1980]. The later approach is more appealing because it is less restrictive.

A strong case can be made that the disturbance terms in 5.1, 5.2, and 5.3 have a cross-sectional error component. It has been argued that futures markets evolve in response to hedging needs. Hedging needs arise in part because of the desire to conduct forward transactions. These needs are likely to be unique to each commodity market since forward trade evolves in response to the changing economic, structural, and institutional setting of a particular commodity market. Since the economic, structural, and institutional forces which affect each market are multidimensional, it makes the discussion of all the structural forces, for instance, impossible.

In the model given by 5.1, 5.2, and 5.3 several of these economic variables appear as exogenous variables in the hedging equation.

Concentration, for instance, is a measurable structural characteristic that can be used to compare cross-sectional differences suggesting the degree of market power that is present. However, there are structural variables not included in the model that affect hedging that may be unique to each market. This happens because of the general nature of the model being proposed where the effect of those factors specific to each market are not a primary concern. However, the presence of these cross-sectional effects has important ramifications regarding the estimation procedure employed.

There are additional reasons for the cross-sectional component. Each of the 16 futures markets is unique in a multi-dimensional sense. Contract stipulations, such as the quantity to be delivered, time and place of delivery are determined to a large extent by the participants. Contract definition can affect hedging and speculative behavior. Earlier a hypothetical wheat contract calling for delivery of a single bushel of wheat was offered as an example of the impact of contract definition on market activity. The factors which determine the stipulations of a commodity futures contract are assumed to be specific to each market. Since the quantification of these commodity specific variables is not possible nor particularly germane to the present problem, a cross-sectional error component is suggested. It could be argued that contract stipulations are in part determined by factors associated with the exchange where the contract is traded. However, exchange information is explicitly entered in the model above obviating the need to rationalize the cross-sectional effects associated with exchange differences.

Error Components Model

In the discussion above it was argued that the disturbance terms in the futures market behavioral model contained a specific cross-sectional

component. This type of model has been addressed in the literature under a class of models commonly called error components or variance-components models [Maddala, 1977]. In single equation models with a cross-sectional error component, OLS estimates of the parameters are inefficient. Consequently, Generalized Least Squares (GLS) is required to obtain efficient parameter estimates. Consider the following cross-sectional and time series single equation model written in matrix notation:

$$(5.5) \quad Y = XB + U$$

where Y = a $(\sum_{i=1}^{n} T_i) \times 1$ vector of observations on the dependent variable,

X = a $(\sum_{i=1}^{n} T_i) \times (K + 1)$ matrix of observations on the explanatory variables,

B = a $(K + 1) \times 1$ vector of parameters,

U = a $(\sum_{i=1}^{n} T_i) \times 1$ vector of disturbances.

There are n cross-sectional units over which observations are recorded. Observe that the time series of observations on each cross-section can vary which implies that 5.4 is unbalanced over cross sections. The disturbance term U can be rewritten to show the cross-sectional error component:

$$(5.6) \quad U = V + E$$

where V = a $(\sum_{i=1}^{n} T_i) \times 1$ vector of disturbances reflecting general ignorance,

E = a $(\sum_{i=1}^{n} T_i) \times 1$ vector of disturbances reflecting specific ignorance.

The assumptions made regarding 5.4 also hold for 5.6 except for the fact that the equation parameter j is omitted.

The variance-covariance matrix is given by the following block diagonal matrix:

$$(5.7)\quad E(UU') = \Sigma = \sigma_\mu^2 \begin{bmatrix} A_1 & & & 0 \\ & A_2 & & \\ & & \ddots & \\ 0 & & & A_n \end{bmatrix}$$

where

$$A_i = \begin{bmatrix} 1 & \rho & \rho & \rho & \cdots & \rho \\ \rho & 1 & \rho & \rho & \cdots & \rho \\ \rho & \rho & 1 & \rho & \cdots & \rho \\ \cdots & & & & & \\ \rho & \rho & \cdots & & & 1 \end{bmatrix}$$

letting $\rho = \dfrac{\sigma_\varepsilon^2}{\sigma_\nu^2 + \sigma_\varepsilon^2} = \dfrac{\sigma_\varepsilon^2}{\sigma_\mu^2}$

The parameter σ_μ^2 is the model variance and is the sum of two components: i.e., the sum of the variance due to the general ignorance and the variance associated with the specific cross-sectional component. Thus, ρ is a ratio which measures the relative size of the variability of the specific ignorance component with respect to the model variance.

The GLS estimator for $\underline{B}$ is given by the following:

$$(5.8)\quad \hat{B} = (X' \Sigma^{-1} X)^{-1} (X' \Sigma^{-1} Y)$$

This estimator is superior to the OLS estimator because it is more efficient which results from the inclusion of the variance-covariance

information. Unfortunately, the matrix Σ is not known and must be estimated as well.

In many single equation applications the Maximum Likelihood (ML) estimator has been used. The likelihood function of U assuming a normal distribution is given by:

$$(5.9)\quad L = (2\pi)^{-\frac{1}{2}\sum_{i=1}^{n} T_i} (|\Sigma|)^{-\frac{1}{2}} \exp(-\tfrac{1}{2}(Y-XB)'\Sigma^{-1}(Y-XB))$$

Taking logs of 5.9 and expanding yields the following (see Appendix D):

$$(5.10)\quad -2\ \log L = \text{const} + \sum_{i=1}^{n} T_i \log \sigma_\mu^2 + \sum_{i=1}^{n} \log\left(1 + \frac{T_i\,\rho}{1-\rho}\right) + (Y-XB)'\Sigma^{-1}(Y-XB)$$

Maximum likelihood estimates of σ_μ^2, ρ, and B are obtained by maximizing 5.10 with respect to these parameters. A technique often employed to solve for the parameters is to search over values of ρ choosing the corresponding parameter set which maximizes the concentrated likelihood function. The concentrated likelihood function is found by taking the first order conditions with respect to σ_μ^2 and B and substituting the results back into 5.10. This is expressed mathematically as follows:

$$(5.11)\quad -2\ \log L = \text{const.} + \log(\sigma_\mu^2(1-\rho))\sum_{i=1}^{n} T_i + \sum_{i=1}^{n} \log\left(1 + \frac{T_i\,\rho}{1-\rho}\right)$$

Using the GLS estimator, estimates of B are obtained for each value of ρ along with corresponding estimates of σ_μ^2. With the corresponding ρ and σ_μ^2 the function given by 5.11 is evaluated. The ρ that maximizes the function is the maximum likelihood estimate of ρ implying that the corresponding $\hat{B}$ and $\hat{\sigma}_\mu^2$ are also maximum likelihood estimates [Maddala, 1977]. Details of this procedure can be found in Appendix D.

Although the ML estimator has many desirable properties, there have been questions concerning its use in the variance-components models. Nerlove [1971] found in a Monte Carlo study that the estimated ρ values were zero when the true ρ was a larger value in the range $0 \leq \rho < 1$. It was argued that the serial nature of exogenous variables interacted strongly with the autoregressive nature of the problem under study causing problems with the estimated ρ values. This is not considered to be a problem in the present analysis, however.

The procedure can be applied to the case of simultaneous equations as well [Maddala, 1977]. Equations 5.1, 5.2, and 5.3 represent the structural equations of the model. OLS estimation of these parameters will yield inconsistent results because the disturbances are correlated with the endogenous regressors. Prior to the direct application of the variance-component model to the structural equations, the correlation problem must be purged. This is done by obtaining the estimated values of the endogenous variables from the reduced form equations. These values replace the actual values of hedging, speculation, and volume. Ordinarily, direct estimation of the transformed equations would yield the normal Two Stage Least Squares (TSLS) results. However, with the presence of the cross-section specific error component the normal TSLS procedure will be inefficient. The suggested procedure is to apply the ML estimator to each of the three structural equations [Maddala, 1977]. For each equation search over the values of ρ and choose the ρ value and corresponding parameter set that maximizes the concentrated likelihood function. Thus, for each equation a set of modified TSLS estimates and a corresponding ρ value are obtained. Since these are ML parameter estimates, the parameters have the corresponding ML properties.

Contemporaneous Correlation

If the disturbances are correlated across equations then a systems approach is required to assure asymtotically efficient parameter estimates. The disturbances of equations 5.1, 5.2, and 5.3 are assumed to be correlated. There are several reasons that suggest the contemporaneous nature of the disturbances. An exogenous shock to the system may affect hedging, speculation and/or volume, but because this exogenous effect was not explicitly included in the model its effects are felt through the disturbance terms. Given the level of abstraction there may be some excluded variables which give rise to the contemporaneous correlation problem. A more compelling reason is the fact that the distinction between what is hedging and what is speculation is not often clear. Some have argued that a continuum exists between hedging and speculation [Ward and Fletcher, 1971]. The legal definition of what is considered hedging has been subject to change over the years tending toward a more lenient interpretation. Since the economic notion of hedging and the legal definition may be at variance, a problem of measurement error arises because observed hedging and speculation are based on the legal definition, whereas the theory is based on economics. A problem of measurement error also is manifest as a result of the allocation of the nonreported data between hedging and speculation. Consequently, the errors of the hedging and speculation equations are expected to be correlated because a measurement error on hedging implies a corresponding error on speculation. Since the procedure used involves using instruments for the endogenous variables appearing as regressors, it is assumed that the errors in variable problem associated with the endogenous regressors is not present.

A method used that incorporates the information associated with the contemporaneous correlation is Zellner's Seemingly Unrelated Regression (SUR) model. Briefly, the SUR model stacks the equations and estimates the system as a whole. In this model the equations are transformed by post-multiplying the vector Y_j and the matrix X_j by $\hat{P}_j$ where $\hat{P}_j$ is a matrix when multiplied by its transpose equals A_j^{-1} for the jth equation. Recall that the matrix A_j^{-1} is estimated by searching over ρ values and choosing the corresponding parameter set that maximizes the concentrated likelihood function. Hence $\hat{P}_j$ is also some function of the ML estimate of ρ. After these transformations the equations are stacked.

Consider the following illustrative model:

$$(5.12) \quad Y_j^* = X_j^* \hat{B}_j^* + U_j^* \qquad j = 1, 2, 3$$

where $Y_j^* = \hat{P}_j Y_j$,

$X_j^* = \hat{P}_j X_j$

$\hat{B}_j^*$ = the parameter vector of the jth equation estimated with the transformed data,

$\hat{U}_j^*$ = a $(\sum_{i=1}^{n} T_i) \times 1$ vector of residuals on the jth equation.

In this model the following assumptions on U_j are made:

a.) $E(U_j^*) = 0 \qquad j = 1, 2, 3$

b.) $E(U_j^* U_j^{*\prime}) = \sigma_{jj} I$

c.) $E(X_j^* U_j^*) = 0 \qquad j = 1, 2, 3$

The disturbance term, U_j^*, is assumed to be serially independent but is correlated with the U_j^* of the other equations. Hence, the variance-covariance structure is depicted as shown in 5.13:

$$(5.13)\quad \Omega = \begin{bmatrix} \sigma_{11}^2 I & \sigma_{12}^2 I & \sigma_{13}^2 I \\ \sigma_{21}^2 I & \sigma_{22}^2 I & \sigma_{23}^2 I \\ \sigma_{31}^2 I & \sigma_{32}^2 I & \sigma_{33}^2 I \end{bmatrix}$$

The dimension of I is $\sum_{i=1}^{n} T_i \times \sum_{i=1}^{n} T_i$. The GLS estimator for the system is given by the following:

$$(5.14)\quad \hat{B}^* = (X^{*\prime}\Omega^{-1}X^*)^{-1}(X^{*\prime}\Omega^{-1}Y^*)$$

In practice Ω^{-1} is not known and must be estimated. Using the residuals from the second stage results, the Ω^{-1} matrix can be estimated. Taking $\hat{\Omega}^{-1}$ and applying it to 5.14 yields a consistent and an asymtotically efficient estimate of B^* [Maddala, 1971].

A Review of the Estimator Choice

The objective is to estimate the parameters of the structural equations given by 5.1, 5.2, and 5.3. It was shown that the equations were overidentified. Further, the disturbance of each equation was argued to have a cross-section specific component. The parameter ρ, which measures the variability of the cross-section component to the total variability of the model, may vary across the three equations because the relative cross-sectional effects differ. In other words, one might expect the relative cross-sectional effects to be greater in the hedging equation than in the speculative equation, because hedgers tend to reflect cross-sectional differences more so than speculators. Speculators may be indifferent between the speculative opportunities of two or more markets. It is also argued that the disturbances across equation were correlated because of the possibility of an omitted variable and

measurement error in hedging and speculation. Consequently, a Modified Three Stage Least Squares (M3SLS) estimator was suggested as a means of estimating the parameters of the structural equations.

There are three stages in the M3SLS procedure. In the first stage the unrestricted reduced form equations are estimated. Using the predicted values of the endogenous variables obtained from the estimated reduced form equations, the endogenous regressors of the structural equations are replaced by an appropriate instrument that is uncorrelated with the respective disburbance. In the second stage the structural equations are estimated separately using an ML procedure to obtain ML estimates of $\sigma_{\mu}^{2}j$, ρ_j, and B_j for each of the j equations. Using a transformation matrix corresponding with the ML estimates of $\sigma_{\mu}^{2}j$, ρ_j, and B_j, the variables of each equation are transformed by the respective transformation matrix. Finally in the third stage the transformed equations are "stacked" and estimated as a system using the residuals of the transformed equations obtained from the second stage to estimate the corresponding variance-covariance matrix.

The procedure used is analogous to the Three Stage Least Squares (3SLS) except for the modification which occurs in the second stage. Most 3SLS models assume that the μ_{it}^{j} are serially independent and contemporaneously uncorrelated across the cross-sections. Consequently, no problems arise in using the TSLS residuals to estimate the Ω^{-1} matrix. However, the $\hat{\Omega}^{-1}$ matrix under 3SLS will be wrong if it is assumed that a cross-section specific error term is present in the disturbances of each equation [Kmenta, 1971]. Consequently, the implimented modification is a way of getting around this problem.

The ML estimator in variance-components models is asymptotically equivalent to the Least Squares with Dummy Variables (LSDV) technique [Maddala, 1977]. However, the LSDV is a less preferred way to handle cross-sectional differences because it assumes that these differences are fixed. It seems reasonable to assume that cross-sectional differences are random just like the general ignorance component of the disturbance term. However, since the estimator properties are based on asymptotic arguments, an implied assumption being made is that the cross-sectional differences are fixed despite the random nature of the vector $\varepsilon_j (j = 1,2,3)$. When the sample includes a large number of cross sections with relative small T_i's, additional estimation problems such as multicollinearity can arise with the LSDV method.

Finally, in the second stage both the dependent and independent variables have been transformed via $\hat{P}_j$. Likewise, the intercept of the original model does not exist for the third stage since X_0^* is not a column vector of ones. The $\hat{P}_j$ can differ across equations but this does not create any problems with the estimation nor with the use of the empirical results. Since all variables within each equation were transformed via the same $\hat{P}_j$, the $\hat{B}_j^*$ are not effected by this adjustment in scale. Hence, it is easy to work back from the third stage structural equations to the reduced forms even though $\hat{P}_1 \neq \hat{P}_2 \neq \hat{P}_3$. These adjustments will be discussed fully in Chapter 6.

A computing alogrithm for the above procedure is given in Appendix F. This program while written in SAS can be easily adopted to any matrix procedure.

Empirical Futures Benefit Model

The econometric model given by equations 5.1, 5.2, and 5.3 was subjected to a sample of 244 cross-sectional and time series observations (the data sets appear in Appendix C). In this section the results of the estimation procedure will be given. Although the third stage estimates are the parameters of interest the results corresponding to the first and second stages of the procedure will also be discussed. Since chapter 6 is devoted to the discussion of the implications of the empirical results especially as they relate to the partial and total effects, the discussion in this chapter will center on the general performance of the models considered.

First Stage Estimates

In the first stage of the estimation procedure the objective is to obtain instruments for the endogenous variables appearing as explanatory variables in the model. This is done by regressing all the predetermined variables on hedging, speculation and volume, respectively. Initially, defining hedging and speculation on the basis of the allocation given by Scheme 1 (see equation 4.1), the equations were estimated using OLS with the results shown in Table 5.1. These results represent the unrestricted reduced form parameter estimates. From the estimated equations the predicted values of the endogenous variables are obtained. Mathematically this is expressed as:

$$(5.15) \quad \hat{Y}_j = X\hat{B}_j \qquad j = 1, 2, 3$$

where $\hat{Y}_j$ = a 244 x 1 vector of predicted values of the jth endogenous variable,

X = a 244 x 15 matrix of observations,

Table 5.1--First stage estimates of the logistic model using Scheme 1 allocation

Variables[a]	Activity Equations[b]		
	Hedging	Speculation	Volume
Concentration (CN)	-.040448 (-1.83)	-.007441 (-.35)	.020590 (.82)
Concen. squared (CN^2)	-.000592 (-1.93)	-.000781 (-2.68)	-.000793 (-2.28)
Firm numbers (FN)	.000004 (1.06)	.000014 (3.46)	.000017 (3.46)
Correlation coef.	-1.378133 (-4.55)	-.147565 (-.51)	-1.074588 (-3.13)
Coef. of variation (CV)	.016251 (.56)	-.099583 (-3.63)	-.073313 (-2.24)
Coef. of var. squared (CV^2)	-.000329 (-.47)	-.001623(-2.44)	.001317 (1.66)
Loan rate (LN)	.379007 (1.01)	-.036389 (-.10)	-.057175 (-.13)
Perishability (FE)	-.690551 (-1.89)	-.257582 (-.74)	-.916709 (-2.21)
Maturation (AG)	-.014722 (-2.48)	.000343 (.06)	.009559 (1.42)
Stock yield (UY)	-.109570 (-1.11)	.145099 (1.55)	-.105377 (-.94)
Spreading (SV)	.047537 (5.19)	.036645 (4.22)	.003634 (.35)
Number of pits (NP)	.039030 (1.65)	-.027970 (-1.24)	.026332 (.98)
Exchange rate (ER)	.190677 (2.97)	.471225 (7.76)	.207927 (2.87)
Time trend (TT)	-.002717 (-.07)	-.016570 (-.50)	-.037237 (-.94)
Intercept	2.983197 (4.12)	1.019839 (1.48)	6.838153 (8.36)
R^2	.62	.68	.53
df	229	229	229
MSE	1.05	.94	1.35
F	26.77	36.20	18.70

[a]See Table 4.2 and Appendix A.

[b]Statistics shown in parentheses are t-values.

$\hat{B}_j$ = a 15 x 1 vector of parameter estimates for the jth unrestricted reduced form equation.

The predicted values of H_{it}, S_{it}, and V_{it} are uncorrelated with the disturbances in the probability limit and will lead to consistent second stage parameter estimates [Maddala, 1971].

Second Stage Estimates

The Sysreg procedure in SAS was used to obtain the $\hat{Y}_i$ which was outputed into a data set to be used in the second stage. In the second stage the objective was to obtain maximum likelihood estimates of the structural parameter vector in light of the assumptions regarding the cross-section specific character of the disturbance as shown in 5.7. Since the estimator used in this stage is not directly handled in SAS, the matrix procedure in this software package was utilized. Details on the estimator can be found in Appendix F. In this stage the endogenous explanatory variables were replaced by their respective predicted values. The GLS estimators were used to estimate the structural parameters of the model. Since the variance-covariance matrix, Σ in 5.7 was not known, it was estimated iteratively. The estimated variance-covariance matrix which maximized the concentrated function was used in the GLS estimation procedure. Searching over values of ρ over the interval 0 - 1.0 at increments of .1, a unique set of structural parameters and model variance are obtained for each equation. The estimate of ρ and the corresponding parameter set are the ML estimates. The second estimates of the structural parameters are shown in Table 5.2, again using allocative scheme 1.

ML estimates of the ρ values appear in Table 5.2. As one might expect the size of the ρ values differ across equation. Since, futures

Table 5.2--Second stage estimates of the logistic model using Scheme 1 allocation

Variables	Activity Equations		
	Hedging (equation 5.1)	Speculation (equation 5.2)	Volume (equation 5.3)
Hedging	--	--	.630700 (3.21)
Speculation	--	--	.190724 (.99)
Volume	1.351200 (5.05)	1.045328 (6.76)	--
Concentration	-.070274 (-1.28)	--	--
Concen. squared	.001610 (2.15)	--	--
Firm numbers	-.000015 (-1.54)	--	--
Correlation coef.	.240274 (.56)	--	--
Coef. of variation	.128447 (3.57)	.057171 (2.01)	--
Coef. of var. squared	-.002279 (-3.05)	-.000989 (-1.55)	--
Loan rate	.201820 (.50)	--	--
Perishability	-1.000636 (-1.30)	.154810 (.30)	.103580 (.14)
Maturation	-.003671 (-.52)	.007166 (1.27)	--
Stock yield	--	.144631 (2.91)	--
Spreading	--	.016814 (1.31)	-.010429 (-.67)
Number of pits	--	--	-.004222 (-.18)
Exchange rank	--	--	.422173 (2.93)
Time trend	--	--	-.049303 (-2.18)
Intercept	-3.628200 (-1.51)	-4.996861 (-2.60)	2.818612 (1.88)
R^2	.59	.71	.74
df	233	236	236
CON[a]	211.015	212.151	279.379
P	.5	.3	.4

[a]CON is the value of the concentrated likelihood function.

markets are tailored to the commercial needs of the potential hedgers, each market should reflect specific information regarding the commercial needs of each market. Recall that the parameter ρ is the ratio of the variance of the specific ignorance component to the total model variance. Thus, a high ρ value implies that much of the model variance arises from specific ignorance relating to differences occurring cross-sectionally. With this in mind it seems more reasonable that the hedging equation would have the highest ρ value. This argument is strengthened by the fact that speculators may be indifferent to the commodity market in which they participate. Clearly, some speculators become skilled traders in some markets trading exclusively in these markets. However, it seems reasonable to assume that speculative dollars are less bound to specific futures markets relative to hedging use of these markets.

The volume equation ML estimate for ρ is .4 which is larger than the .3 value of the speculation equation but smaller than the hedging equation parameter. Each market can be expected to have differing levels of volume reflecting differing liquidity needs. This is influenced to some extent by the hedging and speculative use of these markets. Thus, the ρ parameter in the volume equation partially reflects the cross-section specific information relating to commercial as well as the speculative use of the market. This suggests that the resulting estimate of ρ may be a blend of the cross-section specific information from the other two equations. The fact that the ML estimate of ρ for the volume equation is the average of the other two is support for this view.

It has been suggested in the literature that the concentrated likelihood functions which in this case are mapped over the values of ρ may have extensive flat regions possibly containing local minima which cloud

the search procedure used in solving the variance-components problem [Nerlove, 1971]. In Figure 5.1 the concentrated likelihood functions are shown for each equation over the range of ρ values. Actually these functions are not the concentrated likelihood functions, but are negative functions of them. Hence, these functions reach a minimum rather than a maximum (see Appendix D). It is apparent that the functions are convex to the origin and reach apparent global minimums at the respective ML estimates of ρ (see Table 5.3). The estimated structural parameters are fairly stable in the region of the ML estimate of ρ. In Table 5.4 the estimated parameters of the hedging structural equation are given for the ML estimate of ρ (i.e., $\hat{\rho} = .5$) and neighborhood values of ρ. Only the parameter on the maturation variable changed significantly in magnitude, while in no case was there a sign change. Since the structural parameter estimates would appear to be fairly robust in the neighborhood of the ML estimate of ρ, further refinement in the iterative procedure was deemed unwarranted and costly.

Third Stage Estimates

In the third stage the objective is to obtain a more asymptotically efficient estimator by regressing the equations together as a system. It is argued that the equation disturbances are contemporaneously correlated having a variance-covariance matrix given by Ω as derived in 5.13. Since Ω is not known it is estimated using the residuals from the equations estimated in the second stage. Recall that the variables are transformed by a $\hat{P}$ matrix in the second stage in accordance with the GLS estimation procedure when Σ is unknown. In matrix notation the second stage estimated equations are given as follows (also see equation 5.12):

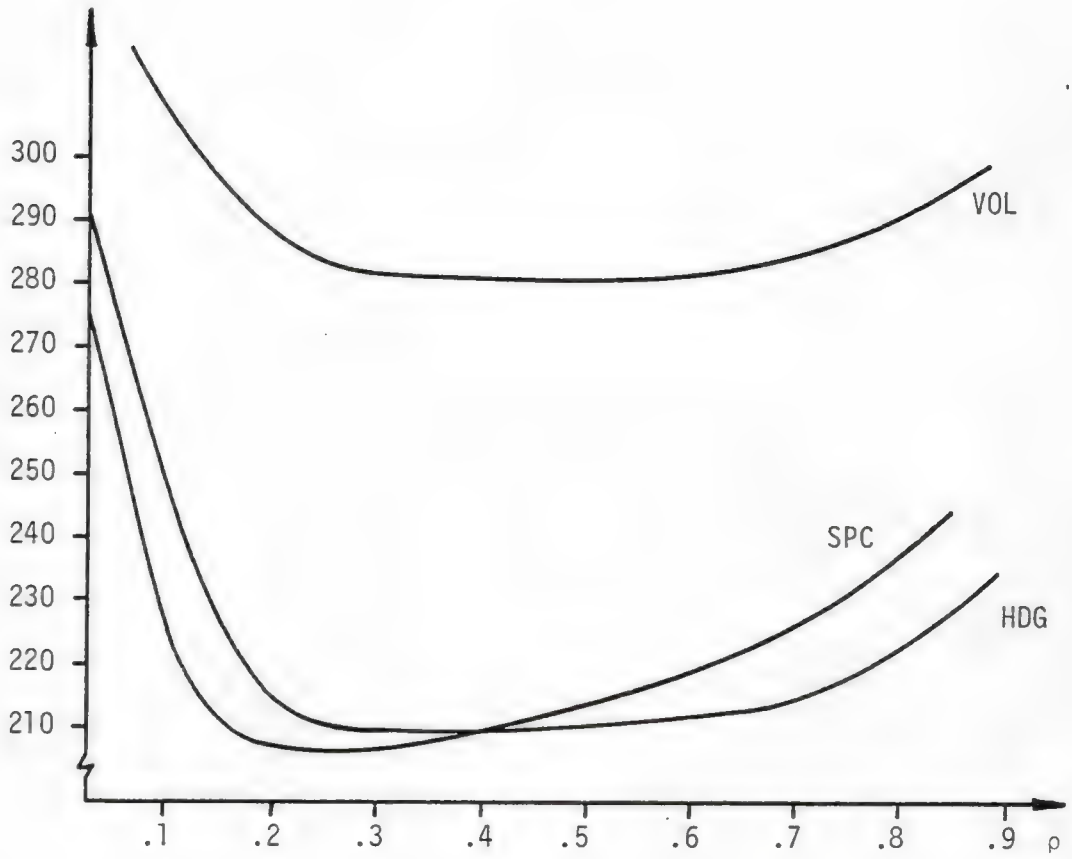


Figure 5.1--Graph of the concentrated likelihood function for the three structural equations (HDG, SPC, and VOL)

Table 5.3--Value of the concentrated likelihood function over the range of ρ (see equation 5.11)

ρ	H	S	V
0	289.84	275.71	338.18
.1	235.36	223.64	294.45
.2	219.99	213.98	284.33
.3	213.74	212.15	280.60
.4	211.29	213.16	279.37
.5	211.01	215.69	279.60
.6	212.33	219.38	281.00
.7	215.25	224.38	283.74
.8	220.34	231.39	288.55
.9	229.96	243.09	298.08

Table 5.4--Robustness of parameters of the hedging equation with changes in ρ

Variables	ρ Value		
	.4	.5[a]	.6
Predicted volume	1.226030	1.351290	1.431190
Concentration	-.066115	-.070274	-.072333
Concen. squared	.001383	.001610	.001795
Firm numbers	-.000015	-.000015	-.000014
Correlation coef.	.182127	.240274	.305244
Coef. of variation	.119894	.128447	.136154
Coef. of var. squared	-.002135	-.002279	-.002410
Loan rate	.250041	.201820	.159069
Perishability	-.942195	-1.000640	-1.051870
Maturity	.005528	-.003671	-.001719
Intercept	-2.892900	-3.628300	-4.366760
CON	211.299	211.015	212.338
σ^2_μ	1.183	1.369	1.662

[a]This corresponds to Table 5.2.

$$(5.16)\quad \hat{P}_j Y_j = \hat{P}_j X_j \hat{B}_j^* + \hat{U}_j^* \qquad j = 1, 2, 3$$

where $\hat{P}_j$ = the transformation matrix which depends on the ML estimate of ρ for the jth equation (the dimension of P_j is (244 x 244)),

$\hat{B}_j^*$ = the ML estimates of the parameters of the jth structural equation,

$\hat{U}_j^*$ = the estimated residuals of the jth equation.

Using the estimated residuals from the hedging, speculation, and volume equations the following variance-covariance matrix is estimated corresponding to equation 5.13:

$$(5.17)\quad \Omega = \begin{bmatrix} 1.30783 & .84675 & 1.22435 \\ .84675 & 1.02159 & 1.00269 \\ 1.22435 & 1.00269 & 1.59489 \end{bmatrix} \otimes I$$

The identity matrix has a dimension of (244 x 244). The third stage estimator can now be written as follows:

$$(5.18)\quad \hat{B}^{**} = (X'\hat{P}'\ \hat{\Omega}^{-1}\hat{P}X)^{-1}\ (X'\hat{P}'\ \hat{\Omega}^{-1}\hat{P}Y)$$

The X, $\hat{P}$, and Y matrices are stacked and have the following form where each X_j includes all endogenous and exogenous variables for the jth equation as shown in Table 5.2:

$$X = \begin{bmatrix} X_1 & 0 & 0 \\ 0 & X_2 & 0 \\ 0 & 0 & 0_3 \end{bmatrix},$$

$$P = \begin{bmatrix} P_1 & 0 & 0 \\ 0 & P_2 & 0 \\ 0 & 0 & P_3 \end{bmatrix},$$

$$Y = \begin{bmatrix} Y_1 \\ Y_2 \\ Y_3 \end{bmatrix}.$$

The third stage parameter estimates are given in Table 5.5. There are several things worth mentioning at this time. First, a cursory glance at the results indicates the model has a reasonable level of explanatory power. The weighted R^2 for the system is approximately 60 percent [Dhrymes, 1974, p. 242]. Although there is no criteria available for statistical inference of the estimated parameters, the reported t-statistics are found to be acceptable for most of the variables. Since the distribution of the estimated parameters is only an approximation of the asymptotic distribution, use of the t-statistics is not quite correct. It is, however, more conservative than using the z-statistics calculated from a normal distribution which is more appropriate to use when the estimator has known asymptotic properties. In addition, a significant amount of pretesting was conducted in the estimation procedure. Under this scenario the distribution of the estimator is not known which makes statistical inference impossible from a purist point of view. Suffice it to say the t-statistics that are reported are an inappropriate criteria for tests of significance, but are generally acceptable on the basis of common practice.

The signs of the parameter estimates were consistent with the theory for the most part. In fact, only one parameter of the model was disappointingly wrong in sign. The speculation parameter in the volume equation was estimated to be -.0574 with a corresponding t-statistic of -.40. Since speculation is generally credited with enhancing liquidity

Table 5.5--Third stage estimates of the logistic model using Scheme 1 allocation (see equations 5.1, 5.2, and 5.3)

Variables[a]	Activity Equations[b]		
	Hedging	Speculation	Volume
Hedging	--	--	.837352 (6.34)
Speculation	--	--	-.057400 (-.40)
Volume	.803818 (4.37)	.925210 (7.59)	--
Concentration	-.064293 (-2.18)	--	--
Concen. squared	.000551 (1.34)	--	--
Firm numbers	-.000013 (-2.22)	--	--
Correlation coef.	-.294997 (-1.06)	--	--
Coef. of variation	.111845 (4.62)	.089330 (4.47)	--
Coef. of var. sq.	-.002115 (-4.49)	-.001709 (-4.02)	--
Loan rate	.359738 (1.64)	--	--
Perishability	.040022 (.06)	.452820 (1.05)	1.001283 (1.68)
Maturation	-.024194 (-5.13)	.003083 (.83)	--
Stock yield	--	.106882 (3.05)	--
Spreading	--	-.001704 (-.19)	0.051425 (4.98)
Number of pits	--	--	-.001967 (-.16)
Exchange rank	--	--	.148609 (1.66)
Time trend	--	--	-.040626 (-2.81)
Weighted R^2 for system = .6002			
Weighted MSE for system = .9089			
Degrees of freedom = 705			

[a]For all data included in the estimation see Appendix C.

[b]Note that in Chapter 4 the exogenous values were expressed according to a logistic model. Hence, all results here correspond to this specification.

this result is discomforting. The fact that there is a technical relationship between speculation and volume is further evidence that the estimated parameter is wrong. However, this empirical result may be saying that the importance of speculation in maintaining liquid markets is overstated. That is a market may need some speculation so that commercial interests can expedite their futures transactions, but beyond that speculation is excessive. In developing markets the need for speculation is clear because it may take time to sort out the hedgers needs. However, as the market matures and hedging needs become well established the need for large amounts of speculation is diminished.

Earlier it was mentioned that there was a problem in the open interest data because a portion of that data is not classified as hedging or speculative. Two allocation schemes were developed to deal with this problem. In the model presented above Scheme 1 allocation was implemented. Recall that Scheme 1 allocates the nonreporting open interest to hedging and speculation on a proportional basis corresponding to the proportion of hedging and speculation open interest in the reported data (see equation 4.1). Under Scheme 2 it is assumed that the proportion of speculation that is included in the nonreporting data is an increasing function of the proportion of the open interest data that is nonreporting. Using the Scheme 2 allocation the model was estimated utilizing the procedure outlined above. The third stage results of this model are given in Table 5.6.

The model using the Scheme 2 allocation does not perform as well as the former model in several respects. Coefficient values on the correlation coefficient and the loan rate variables decreased substantially. In addition, the corresponding t-values became questionably low. Also,

Table 5.6--Third stage estimates of the logistic model using Scheme 2 allocation[a]

Variables	Activity Equations		
	Hedging	Speculation	Volume
Hedging	--	--	.717963 (7.11)
Speculation	--	--	-.080929 (-.55)
Volume	1.184964 (5.03)	.874668 (7.86)	--
Intercept	-.853657 (-.40)	-3.947649 (-3.14)	5.158823 (4.95)
Concentration	-.065060 (-1.38)	--	--
Concen. squared	.000912 (1.48)	--	--
Firm numbers	-.000016 (-1.77)	--	--
Correlation coef.	-.131502 (-.37)	--	--
Coef. of variation	.135020 (4.55)	.094663 (5.86)	--
Coef. of var. sq.	-.002470 (-4.18)	-.001790 (-5.19)	--
Loan rate	.227346 (.76)	--	--
Perishability	-.259098 (-.29)	.357077 (.90)	.915462 (1.58)
Maturation	-.024710 (-3.66)	-.000036 (-.01)	--
Stock yield	--	.089167 (2.78)	--
Spreading	--	.014458 (1.71)	-.031522 (-2.87)
Number of pits	--	--	-.000592 (-.04)
Exchange rank	--	--	.102149 (1.35)
Time trend	--	--	-.045641 (-3.39)
Weighted R^2 for system = .6039			
Weighted MSE for system = .9062			
Degrees of freedom = 705			

[a]See equations 4.2 and 4.3.

there were sign changes in the parameters associated with perishability in the hedging equation and the spreading as well as the maturation variables in the speculation equation. However, the values are relatively low on these parameter estimates and the theoretical arguments on the sign hypotheses are weak. This suggests that these changes should not be used as criteria for choosing a "best" model. Since the loan rate variable and the correlation coefficient are thought to be very important in their affect on commercial use, the model using Scheme 2 is generally viewed as inferior because of the poorer performance in the parameter estimation on these variables.

The model was also estimated under an exponential functional form specification. The results of this model, estimated under the Scheme 1 and Scheme 2 allocation procedures, appear in Appendix E. Although the exponential model estimated under the Scheme 1 has superior results based on the reported t-values there are two serious drawbacks of the exponential functional form. One problem is that the function does not have an upper limit which is contrary to the definitions of hedging, speculation and volume. Since they are expressed in percent of total supply it is possible that predicted values of these variables using the exponential specification could fall outside the 0 - 1 interval. In addition the exponential function does not contain an inflection point as does the logistic functional form. This is a preferred attribute in view of the arguments made earlier in the discussion on the choice of functional form. Also, the estimated ρ parameter for the hedging equation was .4 which is more difficult to explain in light of the definite cross-sectional differences especially with regard to commercial use of futures markets.

Summary

In this chapter both econometric estimation problems and empirical results for the futures trading model were setforth. A simultaneous system using pooled cross-sectional and time series annual data were used. The three equation system was estimated assuming a logistic type structural form using two allocation schemes for dealing with nonreported trader commitments.

Taking these econometric results, the next chapter is devoted to a detailed analysis of the implications and usefulness of the results. Policy issues from changing endogenous and exogenous effects are discussed fully.

CHAPTER 6

POLICY IMPLICATIONS AND TRADING RESPONSES

In this chapter the results of the econometric analysis will be further scrutinized. The chapter is divided into three sections. In the first section the empirical estimates of the partial effects will be evaluated relative to the hypotheses setforth in Table 3.1. A series of simulated response functions will be presented to facilitate the analysis of the partial effects. In the following section the analysis centers on the total effects. The nature of the total effects is a primary concern because these effects measure the total adjustment of hedging, speculation, and volume to exogenous shocks. In the last section a speculative index, which attempts to capture the markets need for speculative activity, is presented. Adjustments in a speculative index in response to exogenous shocks will be investigated.

The Partial Effects

In this section there are two objectives that will be accomplished. One objective is to discuss the statistical significance and the sign appropriateness of the parameter estimates in light of the signs hypothesized in Chapter 4. A second objective is to present a simulated partial adjustment function for the important cases showing the partial effect of a change in an exogenous variable on a particular endogenous variable. In order to accomplish this task it is assumed that the model estimated is deterministic. Moreover, all variables other than the one

under investigation are observed at their mean values (see Table 6.1). In this manner it is possible to observe the adjustments of a given endogenous variable about some "average" level in response to an exogenous variable that is allowed to vary.

Partial Effects of the Hedging Equation

Concentration firm numbers and hedging

Concentration was hypothesized to be related to hedging in a quadratic manner as outlined in Table 4.2. To capture this effect first and second degree polynomial terms on concentration were used in the estimation procedure. The estimated parameters corresponding to these terms were shown in Table 5.5 to be -.0642 and .000551, respectively. The reported t-values suggest that the effect of concentration is significant.

More gratifying than the level of the t-values is the direction of the sign on both parameters. The signs correspond to the theoretical arguments suggesting that initially an increase in concentration increases the level of hedging activity, but at higher levels of concentration the deleterious effects of imperfect competition reduces hedging activities. This relationship can be seen more clearly by looking at the adjustment function in Figure 6.1. The mathematical form of the relationship depicted below is given by the following, again using Table 5.5 with allocation Scheme 1:

$$(6.1) \quad H^* = 1/(1 + EXP(3.23 - .0642CN + .000551CN^2))$$

where H^* = hedging open interest expressed as percent of total supply (see equation 4.23),

CN = the level of concentration expressed in percent,

Table 6.1--The model variables with univariate statistics[a]

Variable	Mean	Standard Deviation	Minimum Value	Maximum Value
Concentration	34.778	14.757	1.000	57.000
Firm numbers	4704.586	20,921.898	36.000	146,220.000
Correlation coefficient	.768	.305	-.400	1.000
Coefficient of variation	10.678	8.236	.380	49.200
Loan rate	.399	.423	0.000	1.200
Perishability dummy	.819	.385	0.000	1.000
Maturity	53.598	36.567	2.000	108.000
Yield on utility stocks	5.797	1.990	2.370	7.900
Spreading variable	88.431	12.990	44.470	99.000
Number of pits	9.131	5.908	1.000	23.000
Exchange rank	2.360	1.630	1.000	6.000
Time trend	10.303	5.122	1.000	18.000
Hedging[b]	.094	.090	0.000	.428
Speculation[b]	.076	.096	0.000	.459
Volume[b]	.015	.018	0.000	.104

[a]See Appendix C for data on each commodity included in the analysis.
[b]Trade activities are expressed as a percent of total supply.

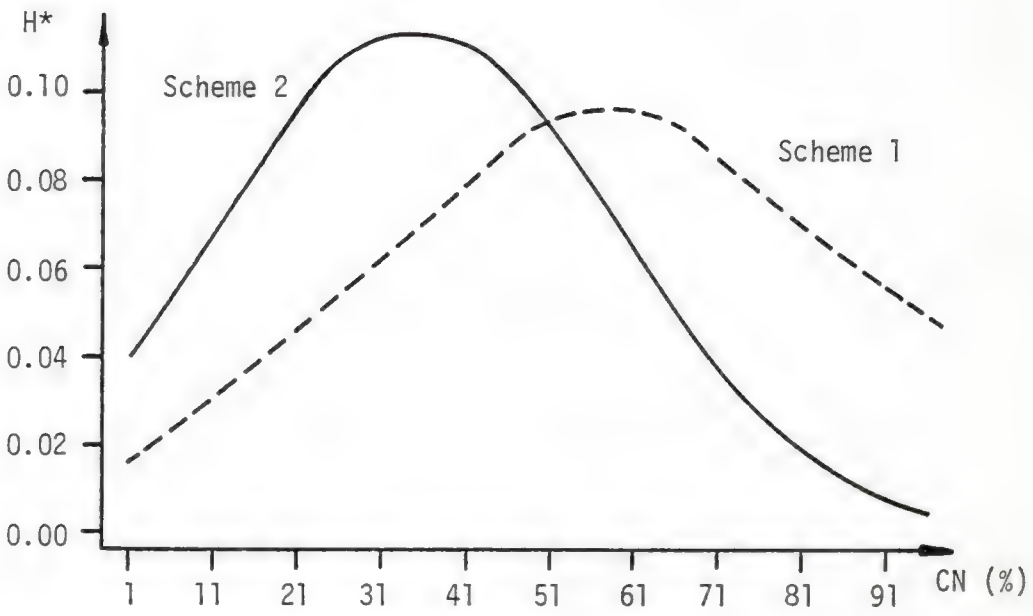


Figure 6.1--The simulated partial effects of concentration

3.23 = a constant that equals the sum of the means of the structural variables (not including the concentration variables) of the hedging equation multiplied by their respective parameter estimates. That is, the parameters from Table 5.5 times the means in Table 6.1.

The simulated partial effects of concentration as it is allowed to vary from 0 to 100 percent are also presented in tabular form in Table 6.2.

Table 6.2--The simulated partial effects of concentration[a]

Hedging (H*)	Concentration (CN)
1.5	0
2.7	10
4.3	20
6.1	30
7.7	40
8.9	50
9.1	60
8.5	70
7.2	80
5.4	90
3.7	100

[a]Derived using equation 6.1.

There are several points of interest concerning Figure 6.1. First the function under the Scheme 1 allocation has a maximum at CN = $\frac{.0642}{2(.000551)}$ or at a concentration level of approximately 58 percent. Beyond this

point the price effects of imperfect competition become evident as hedging activities are restricted. At concentration levels below 58 percent the effect of firm size, which embodies the notion of scale economies in the use of futures markets, dominates the so-called price effect leading to increased hedging activities with small increases in concentration. At small concentration ratios hedging use approaches zero suggesting atomistically organized industries cannot support an active futures market. At the other extreme (i.e., CN → 100) the structure is too concentrated to support a futures market as hedging activity is obviously diminished. The reader is referred to the discussion of concentration found in Chapter 4.

In the figure above the adjustment function corresponding to the model using the Scheme 2 allocative procedure is also shown. The maximum of this function occurs at CN = $\frac{.065}{2(.00091)}$ or at a concentration ratio of approximately 35 percent. This is quite a difference from the maximum associated with Scheme 1 allocation. Unfortunately, one would hope that concentration ratio associated with the extremum would be fairly robust across models. Intuitively, it does not make sense that the function should shift back under Scheme 2 which allocates more of the nonreporting data to speculation. There is the problem that the concentration variable does not measure the effects of market power well, however. This problem could account for the seeming lack of robustness between the models which are distinguished by the definition of hedging and speculative open interest.

To put the concentration numbers into perspective a partial list of the sample concentration ratios is presented in Table 6.3. The industries associated with soybean processing are the most concentrated

Table 6.3--Concentration ratios of selected industries

Industry	SIC Code	1967	1972
Soybean oil	20751	55	51
Soybean cake, meal and other byproducts	20752	56	53
Prepared feeds	2048	23	23
Weaving mills	2211	30	31

industries included in the sample. With ratios approaching 58 percent it is likely that the large commercial interests in these industries may be exerting sufficient market power to restrict hedging use. All of the concentration observations in the sample fall in the below 58 percent category, however.

In light of the findings on the effect of concentration it is apparent that there may be a problem concerning the future of the futures industry in a dynamic structural environment. Among those industries trending to greater levels of concentration there is some question regarding the survivability of futures markets that are beset by commercial interests exerting market power. In some industries the trend to bigger and fewer firms is justified on economic grounds, such as the case of the natural monopoly model. However, in other cases the manifestation of market power raises questions regarding economic efficiency not to mention questions concerning the distribution of resources.

Public policy dealing with these questions emanates primarily from the Federal Trade Commission (FTC). The results of this analysis suggest

that FTC antitrust policy should reckon with the concentration-hedging activity causal relationship, where it is relevent, or face the possibility that the implemented policy may not achieve the desired result. For example, a policy oriented towards the maintenance of atomistic structures may forestall the development of an organized futures market, which can offer market solutions to economic problems, such as income and price uncertainty as well as resource allocation. It may be the case that the presence of futures markets inhibits market power growth. Although this possibility was excluded in this analysis it could serve as a basis for further research.

The econometric models clearly show that concentration influences the use of futures markets. While the results vary somewhat with the allocative scheme for nonreported commitments, the general conclusions remain intact. That is, futures market use in fact increases somewhat with market concentration. Beyond a point, however, the monopolistic effect reduces its usefulness.

The effect of firm numbers on hedging is illustrated in Figure 6.2. Simulating firm numbers from 50 firms to 5000, the level of hedging adjusts from 6.5 percent of the potential hedging (i.e., total supply) actually hedged to 7 percent. In the theory chapter it was hypothesized that an increase in firm numbers increases the benefits of the hedging use of futures markets because the possibilities for other forward exchange arrangements becomes more complex. This may increase the search costs for those seeking forward contractual arrangements. Hence, use of a liquid market becomes more advantageous. This view is supported by the adjustment in hedging shown below.

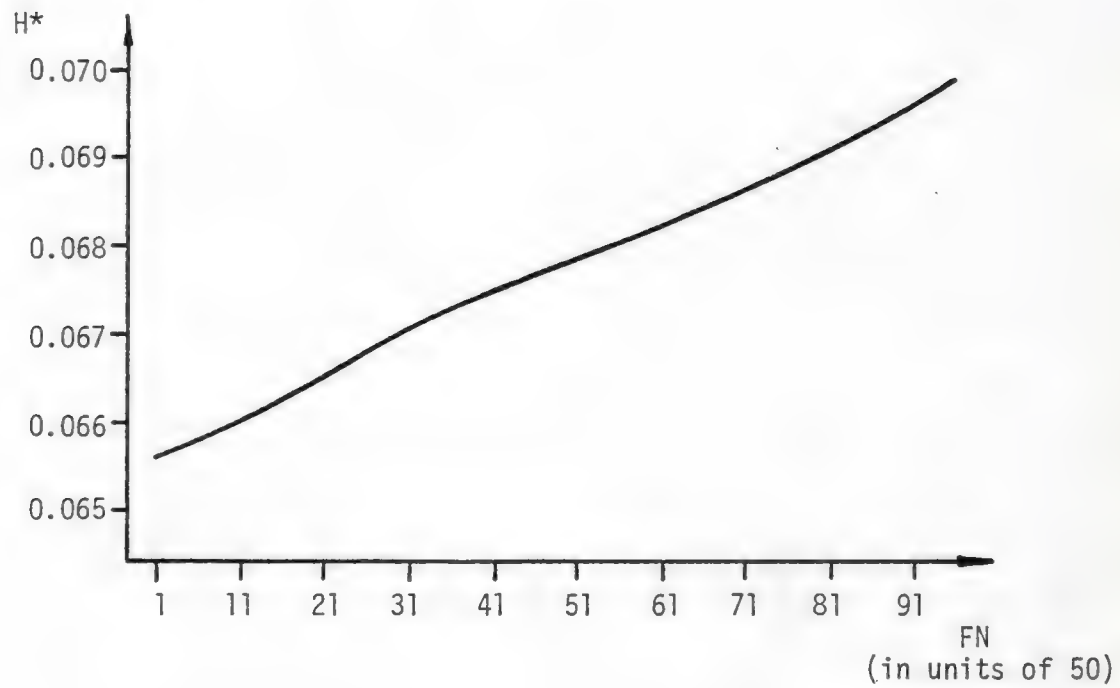


Figure 6.2--The simulated partial effect of firm numbers

Observations on firm numbers range from 36 FCOJ processors to numbers exceeding 100,000 in the case of the feeder cattle market. Although markets such as FCOJ and the soybean product markets appear to support rather successful futures markets, there may be room for concern if further attrition in firm numbers occurs. If recent history is a guide this may be a real problem for existing markets. The effect is important, however, only to the extent that the numerical change shown in Figure 6.2 is a real consequence to a particular industry.

Correlation coefficient and hedging

The correlation coefficient variable is a measure of the hedging effectiveness of futures markets. In the theory chapter it was argued that the futures-cash price spread in the delivery month of a contract relates to the performance of a hedged position. A high correlation between these prices is suggestive of a relatively effective hedge [Ward and Schimkat, 1979]. It is evident from the model results presented in Table 5.5 that the estimated parameter on this variable has the appropriate sign. This relationship is also shown in Figure 6.3 below. The relationship suggests that as the cash-futures price correlation coefficient ranges between zero and 100 percent (i.e., perfect correlation) actual hedging as a percent of potential adjusts from 5.75 to 7.25 percent, ceteris paribus.

The effect of the correlation coefficient as depicted in the figure is somewhat misleading, however. One would expect that hedging use of a futures market would be severely restricted in markets where the cash-futures price correlation was weak. From the figure it appears that hedging use is diminished with weak price correlation, but the diminuation is not a severe level. An explanation of this rests in the fact that

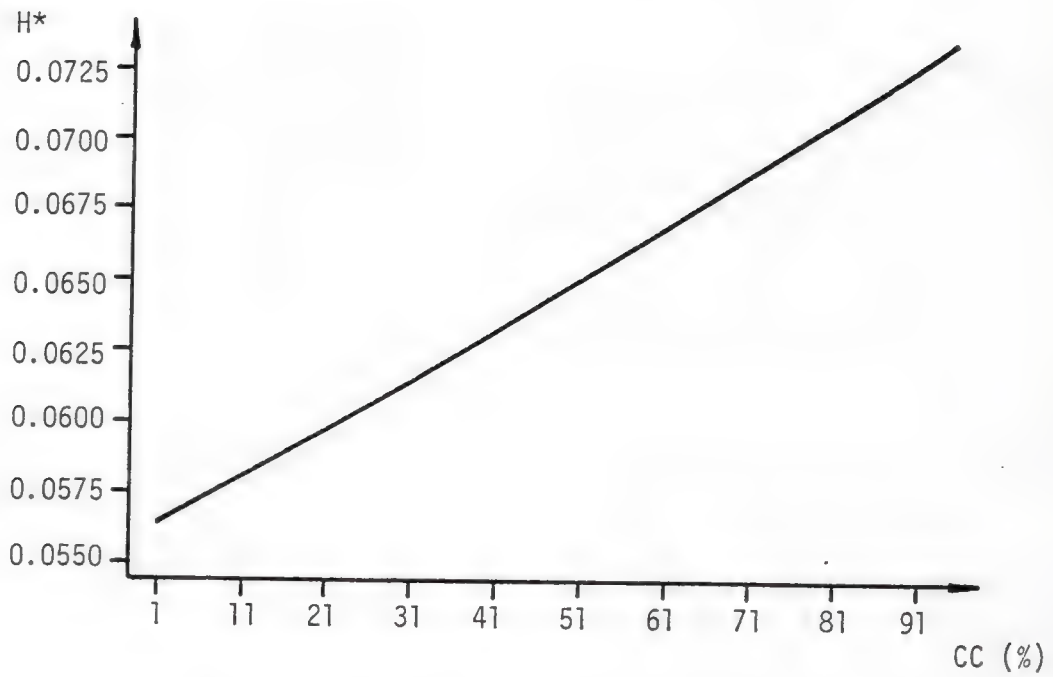


Figure 6.3--The simulated partial effects of the correlation coefficient (CC)

the observations on the correlation coefficient are generally greater than 50 percent. Looking at Table 6.1 it can be seen that a significant number of the observations are quite high. Since most of the observations appear at these upper levels it may not be possible to obtain an adjustment function which fully captures the effect of low correlation coefficient levels. In other words the information in the sample may not be rich enough to adequately explain the effects of the correlation coefficient at all ranges. The low t-value is offered in support of this argument. Since the markets included in the sample are successful it follows that high correlation coefficients would be a characteristic of the data. Hence, there may not be enough variation to estimate the full effect of this particular variable.

Price risk and hedging

A quadratic relationship between hedging and price risk was hypothesized initially in Chapter 4. The estimated partial adjustment function showing the effect of the coefficient of variation in hedging is given as follows and is calculated in a similar manner of that of 6.1:

$$(6.2) \quad H^* = 1/(1 + EXP(1.64 + .1118CV - .00211CV^2))$$

The function is illustrated below with Figure 6.4. Note that the extreme value occurs at $CV = -\frac{1}{2}\left(\frac{.1118}{-.00211}\right)$ or approximately 28 percent. This suggests that the cost effects of price risk dominate the benefits traders receive from conducting forward transactions in a liquid market at CV levels below 28 percent. Again, recall the discussion in Chapter 4. However, observe that the function is relatively flat between zero and 28 percent implying a region where the cost side effect is offset by the benefit effect (Table 6.4).

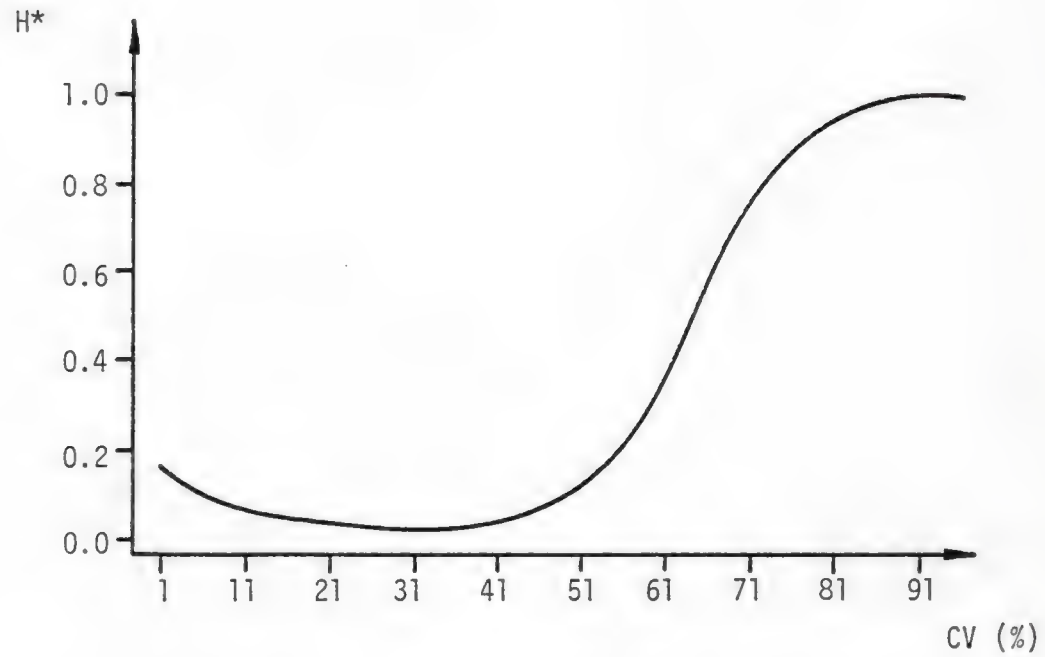


Figure 6.4--The simulated partial effects of the coefficient of variation (CV)

Table 6.4--The simulated partial effects of the coefficient of variation

Hedging (H*)	Coefficient of Variation (CV)
.162	0
.104	5
.072	10
.055	15
.046	20
.042	25
.043	30
.049	35
.061	40
.084	45
.125	50
.710	75
.999	100

One might argue that the positive response of hedging to the coefficient of variation ought to begin at a lower level than the 28 percent estimate. Since it is well established that futures markets are useful because of the risk shifting capabilities, it seems intuitive that the estimated function should be positively sloped throughout. However, there are two reasons why this may not be true. In the empirical work of this analysis the value of 28 percent was fairly robust. Consider, for instance, the corresponding estimate derived from the Scheme 2 allocation model. From Table 5.6 it is apparent that this estimate is approximately 27 percent which is suggestive of robustness. Even the exponential models showed a similar result regarding the minimum of this partial adjustment function (see Appendix E). Hence, the quadratic relationship and the corresponding extremum is strongly supported by empirical work.

Secondly, at low levels of price variability hedging may not be too responsive to the coefficient of variation. Existing and/or developing markets require some degree of price volatility to insure success. Given the presence of price variability the benefit of a futures market rests in the capacity to provide a liquid means to facilitate forward trade. At low levels of price variability the flexibility hedgers would enjoy in a liquid forward position may be relatively small compared to a standard forward contract or other means of forward exchange. Since prices are relatively stable under this scenario there is only minimal risk of losses by entering a forward contract. The advantage of being liquid may not be that important at these levels. However, at higher levels one can expect that the advantage of being liquid becomes important especially when one considers the opportunity

cost of a fixed price forward contract with prices moving adversely during the contract period. In view of these arguments the downward sloping relatively flat region of the adjustment function at low CV levels is not so surprising.

Markets need price uncertainty to support a futures market and encourage hedging use. Observations on the coefficient of variation over the sample period ranged from .38 to 49.2 percent with a significant portion of these data points falling below the 28 percent level. The results suggest that the effect of price variability on the markets included in the sample may not be that great. Although the nonstorable commodities in the sample tended to have higher levels of CV, hence there is little reason to expect that this would encourage hedging in these markets. Clearly, the futures market requires price uncertainty to survive. However, it is apparent from the results that it may take abnormally high levels of price variability to increase hedging beyond some normal level, ceteris paribus.

Loan rate and hedging

The loan rate variable is designed to capture the effect of government on futures market activity through its price support activities. As the ratio of the loan rate to the mean cash price approaches unity it is argued that hedging activities are constricted. The estimated relationship between hedging and the loan rate variable is illustrated in Figure 6.5. As expected the estimated relationship is shown to be inverse. The t-statistic on the relevant parameter is 1.64 (see Table 5.5).

The effect of the loan rate variable is most visible when one considers the cotton market (Table 6.5). Although it is not possible to isolate all of the factors which influence hedging activity in the cotton market, the relationship between hedging and the effect of government is

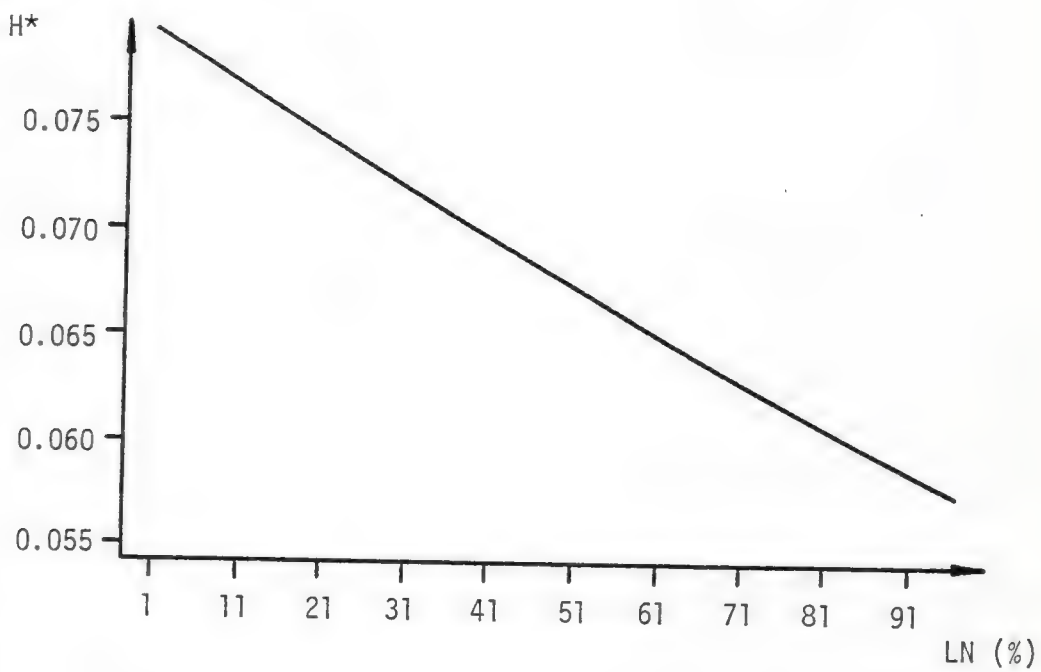


Figure 6.5--The simulated partial effects of the loan rate variable (LN)

Table 6.5--Effect of price support policy on cotton futures market

Year	Hedging[a]	Loan Rate Variable (%)
1961	4495.6	93.8
1962	6308.4	95.3
1963	3876.1	95.3
1964	1096.3	96.2
1965	386.0	93.9
1966	207.0	94.2
1967	0.0	88.2
1968	8701.2	81.1
1969	8686.7	86.4
1970	3617.3	90.6
1971	8059.9	85.6
1972	24494.0	66.1
1973	25116.1	66.0
1974	28077.9	35.9
1975	21689.8	59.9
1976	28603.7	65.1
1977	38638.2	53.7
1978	47389.1	85.1

[a]Hedging is expressed in total open interest.

easily seen in Table 6.5. In the 1960's the price levels for cotton tended to be near support levels. Consequently, the need for short hedging is clearly diminished. In the mid 1960's there was virtually no futures market activity in cotton, a fact that has been attributed to the government price support policies [Hieronymus, 1971]. In the 1970's the situation in the cotton market changed considerably as hedging activity increased significantly, corresponding to higher cash prices relative to support levels.

Figure 6.5 illustrates that a positive level of hedging activity can be expected even if cash prices are held at support levels. In addition it appears that the adjustment is relatively constant over simulated values of the loan rate variable. Intuitively, one would expect that the level of hedging activity to fall rather rapidly when cash prices approach support levels. The problem with the estimated relationship is not so much a weak theoretical argument, but rather a problem with the data. Seven of the 16 markets in the sample were governed by price support programs. Consequently, there were 9 markets that have no price supports which implies a lot of zero values for the loan rate variable. Thus, the estimated relationship between hedging and the loan rate variable is obviously influenced by this informational problem. In addition for markets that are affected by price support policy the observed loan rate variable is generally greater than .5. This makes estimation of a function ranging over a continuum of LN values difficult.

Despite the empirical problems the finding that the effect of government price support policy on hedging is consistent with the hypothesis is quite important. The results suggest that government price support policies in effect assume the risk-shifting role of futures markets.

It can be argued that support programs are directed at abating the income and price instability problems that farmers face. Since it is likely that farmers do not use futures markets as much as larger processors or other middlemen, the direct benefit from the presence of a futures market are somewhat less for farmers. This says nothing, however, about the indirect benefits. Thus, farmers may need public assistance of one form or another to combat income and price instability. Clearly, however, an effective price support program is detrimental to the longevity of futures market activity. Other programs, which are also developed to alleviate the chronic farm problems previously mentioned, may not affect futures market activity or the economic functions it provides. Whether these programs are deemed preferable to the loan program is open to question. However, public debate should include inquiry into the effects of government policy on futures market activity. Ignoring this effect jeopardizes the policy results since the futures market plays a very important role in the economic activity of commodity markets.

Maturity and hedging

In was argued in Chapters 3 and 4 that newly developed markets enter a maturation process as participants become more acquainted with the market. The estimated adjustment function, which is depicted in Figure 6.6, supports this view. Interestingly, the estimated maturation process does not taper off as one might expect. In the theory chapter it was suggested that a market may have a growth period in the early years of development corresponding to a normal market maturation process. The length of this growth period was not hypothesized, but the allusion was given that this period was not long, possibly less than a decade.

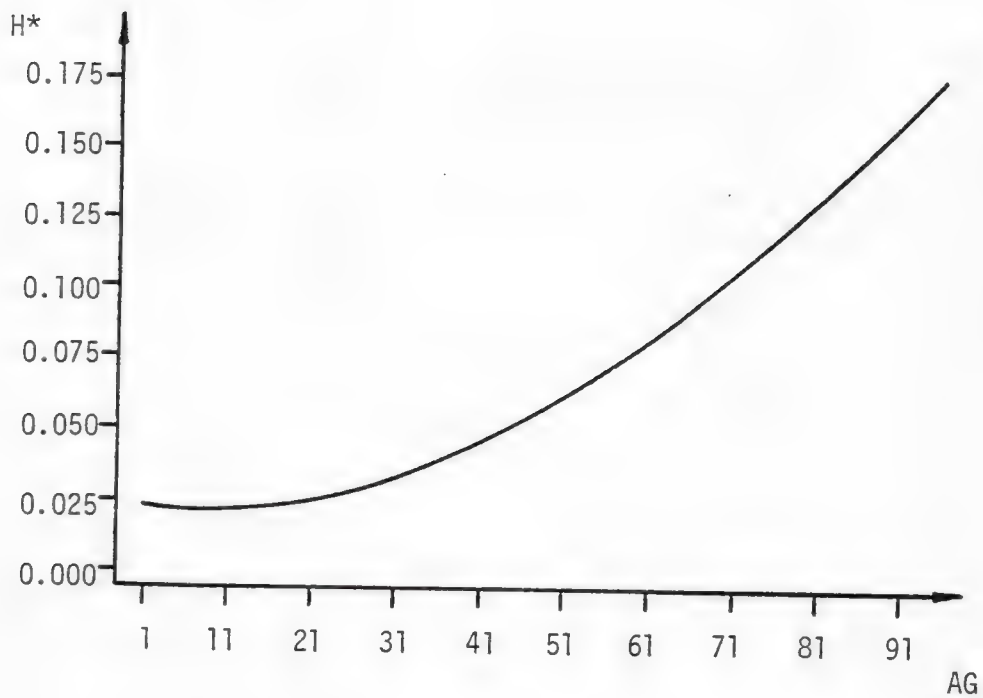


Figure 6.6--The simulated partial effects of age (AG)

This is contrary to Figure 6.6 which suggests that the maturity process is at least 100 years in length. If maturity had no effect on hedging beyond say 10 years, the observed adjustment function with respect to age would contain a corresponding flat region. This is not the case, however, which makes this result so surprising. Moreover, this response is consistent across the other models that were estimated (i.e., the Scheme 2 model and the models with logged endogenous variables).

A long maturation process as suggested by the results have several important implications. One implication is that commercial interest may be slow to learn the mechanics of futures markets as well as appropriate hedging use. This suggests that educational programs designed to enhance the understanding of futures markets could serve to speed the maturation process. Markets as old as wheat and corn could benefit from these sorts of programs. Use of the market to its fullest potential improves the pricing function, as increased commercial use will better reflect the underlying commodity supply and demand conditions in the futures price discovery process. The arbitraging capability of commercial activity will also enhance market liquidity.

Volume and hedging

An increase in volume leads to an enhancement of liquidity which reduces the cost of hedging. Markets that are highly liquid are expected to have considerable hedging use, ceteris paribus. The estimated adjustment function showing the partial effects of volume on hedging confirms this hypothesis (Figure 6.7). At low volume levels hedging activities are low relative to potential hedging use, but it is evident that hedging activities would increase given a more liquid market. The importance of liquidity in attracting hedging use is a point that cannot be labored.

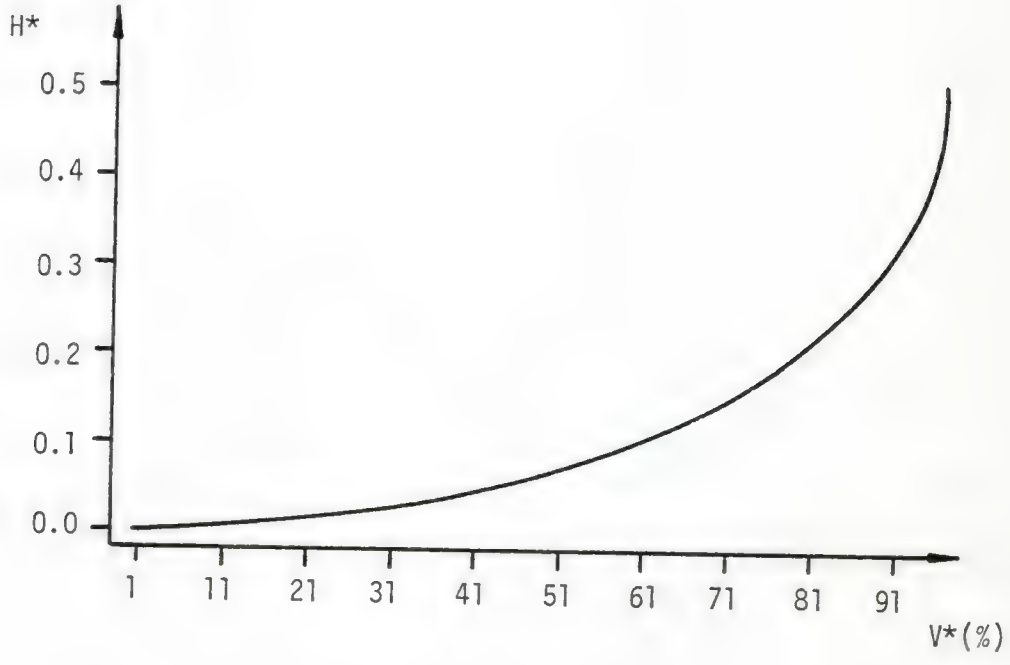


Figure 6.7--The simulated partial effects of volume (V*)

It is a major theme throughout Working's research and in recent work by Telser [1980]. Looking at Table 5.5 the t-statistic on the volume variable is rather large. This represents additional empirical evidence on the importance of liquidity to hedging needs and the ultimate success of a futures market.

Volume arises from transactions by hedgers and speculators establishing futures positions. If a market is characterized by low volume it suggests that hedgers and speculators are not very interested in establishing futures positions. Given this scenario a futures market may eventually succumb to inactivity as the lack of liquidity increases the cost of using the market for hedgers and speculators. The relationship in Figure 6.7 is drawn for values of volume considerably beyond the historical range of volume. However, the figure clearly illustrates the importance of liquidity. If volume were plotted over the historical ranges, an almost linear relationship to hedging would be apparent. Also, if one could substitute the parameter estimates back into the initial net benefit function, it becomes apparent that these benefits approach zero as volume approaches zero (see Appendix G for relationship between the net benefit function and the mathematical models).

The relationship of volume to hedging provides strong support and reinforces exchange policies and related institutions for developing programs to directly enhance trading volume. Not only does it increase turnover of commitments, but it increases the total commercial commitments in futures. New contracts, educational programs, mechanization, etc. are all ways to enhance volume.

Price risk and speculation

A quadratic relationship between speculation and the coefficient of variation was hypothesized (see Chapter 4). The estimated partial adjustment function showing this quadratic relationship is depicted in Figure 6.8 using the results from Table 5.5. A minimum occurs at CV = $(-\frac{1}{2})^{-}(\frac{.089}{.0017})$ or approximately 26 percent. It is interesting to note that these parameters correspond to the estimated CV parameters in the hedging equation (see Table 5.5). The position of the function's minimum is very close to the result found in the case of the partial effect of CV on hedging. This similarity is complemented with relatively large t-values. Also, the parameters estimated under the Scheme 2 allocation model are virtually identical to the estimated CV parameters of the Scheme 1 model (i.e., compare Table 5.5 to 5.6). The robustness of this estimated relationship provides empirical support for the hypothesized quadratic relationship.

The partial adjustment function shown is characterized by a downward sloping relatively flat region at CV levels less than 26 percent. Low CV levels may not encourage significant speculative activity because the chance of windfall gains are relatively low. Transactions costs incurred by speculators in their market activities may exceed expected returns at the margin because the possibility of large movements in price is small. Hence, other investment opportunities are sought. This may be especially true of small speculators since unit transactions costs are typically higher on small transactions. At higher levels of CV the potential for windfall gain attracts speculation at an increasing rate then at a decreasing rate as seen in Figure 6.8.

The bulk of the data on CV, as mentioned before, is less than 26 percent. In this region the futures market cost effect outweighs the

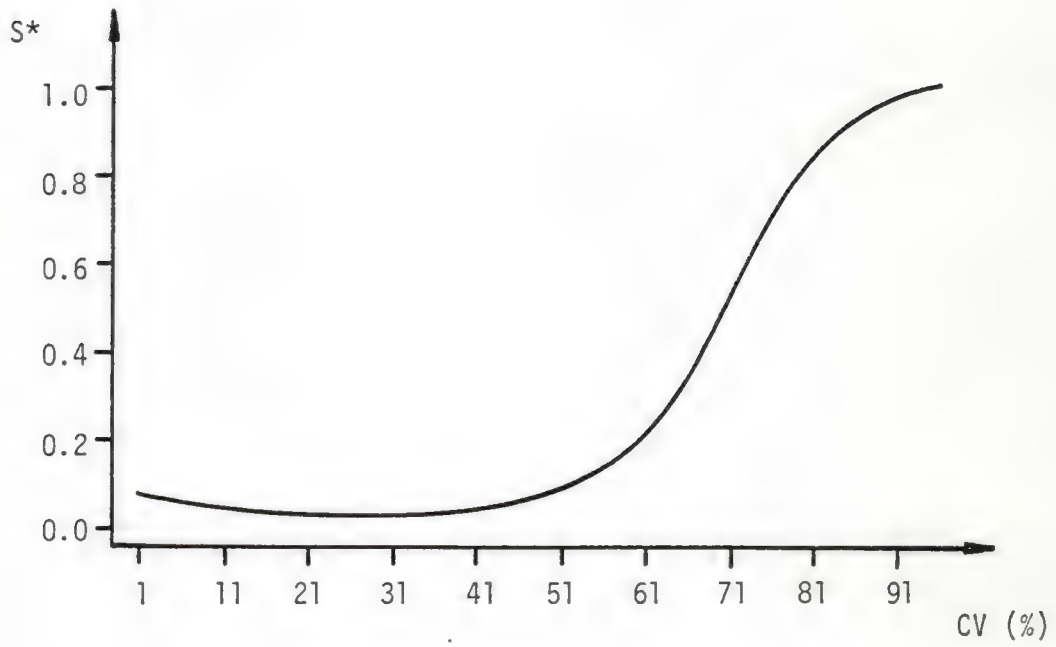


Figure 6.8--The simulated partial effects of the coefficient of variation (CV) with respect to speculation

benefits of futures trading for speculators. That is default risk resulting from members trading for clients dominates the speculative benefits of holding futures contracts. Default risk increases in response to increased price volatility. To combat such risk margin requirements amounting to a small percent of the contracts' value is put up as security by the nonmember trading participants. The security deposit can be adjusted according to the risk levels of a given market. Hence, an increase in risk would suggest higher security deposits which has a negative impact on the speculative trade. However, looking at the figure below this effect is nominal. Since most of the CV observations fall in this area one would have to say that the effect of CV on speculation is not very important. In other words speculators may be indifferent between speculating in markets that vary in risk level over some range of risk. Yet its importance becomes evident as CV approaches the upper limits.

Yield on utility stocks and speculation

As expected rates of return on alternative investments increase, speculative dollars are drawn from futures positions (see Chapter 4). The results suggest that speculative activity is sensitive to return rates on other investment media. This relationship is drawn below in Figure 6.9. Using returns on utility stocks as an alternative investment, yields approaching 20 percent would appear to severly restrict speculative activity. In fact speculative activity is sensitive to the yield on utilities over the entire range of possible yield values. This is an important finding in view of the volatility of interest rate levels which has characterized money markets recently. If speculative dollars are responding to these rates futures markets activity may be

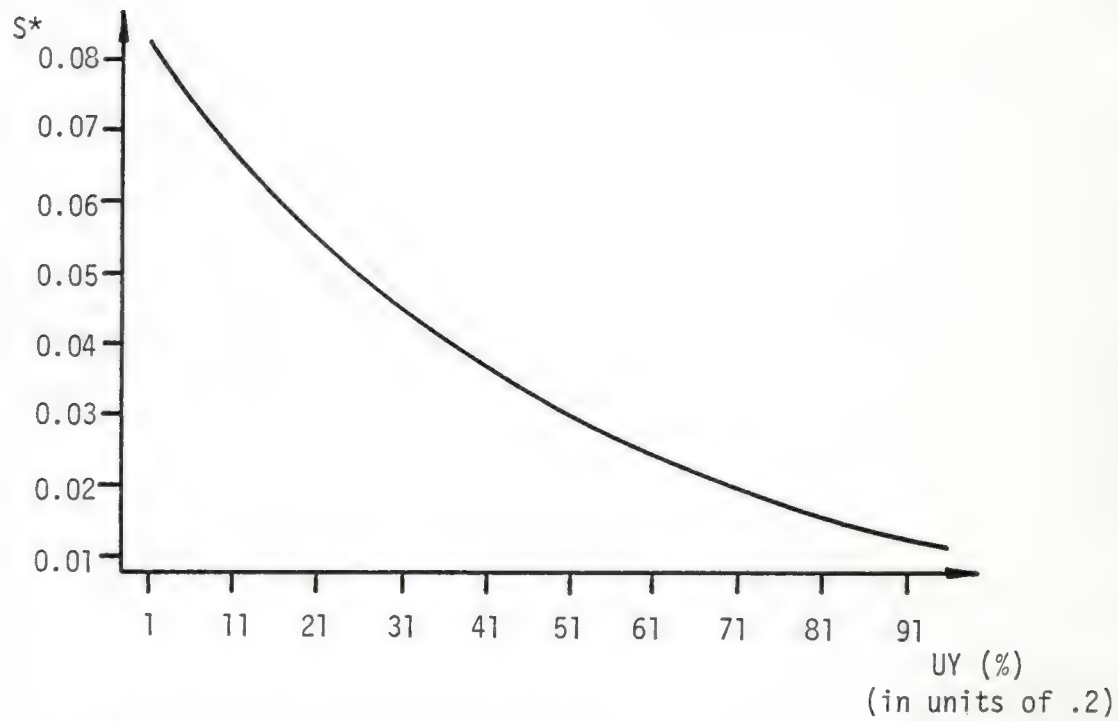


Figure 6.9--The simulated partial effects of the utility yield

disrupted as speculators react. Price distortions may arise which could affect the production, marketing, and distribution process of the commodity.

It is evident that recent events in the money markets may have had a strong influence on speculative behavior in futures markets. Whether these events have caused pricing problems or affected the allocative function depends on what has also been occurring with the other variables entering the speculation equation. Holding all other factors fixed, these results point to a clear link between activity in futures markets and activity in other speculative investment instruments.

Volume and speculation

Like hedging activities, speculation requires liquid market conditions. Recall that liquidity measures the distribution of the market clearing price about the true equilibrium. Liquid conditions imply not only a small distribution but also that the futures price is reflecting fundamental supply and demand conditions. Speculators need assurance that futures prices are responsive to the forces of supply and demand or else face increased risk in holding futures contracts. In the figure below the estimated response of speculation to volume is shown (Figure 6.10). The graph supports the view that speculators are attracted to liquid markets. This partial adjustment function is given further empirical support in light of the reported t-statistic which was on the order of 7.59. More details on this response are covered when considering the total effect.

Maturity, spreading and speculation

The age variable in the speculation equation has an estimated coefficient of .003 suggesting an inverse partial adjustment relationship

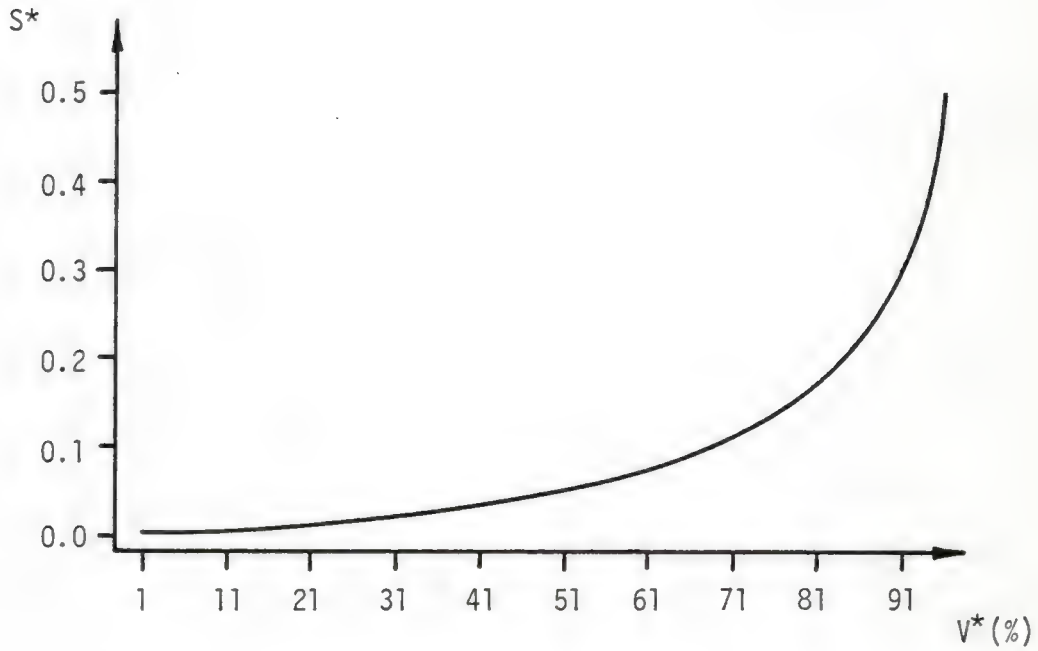


Figure 6.10--The simulated partial effects of volume (V*) with respect to speculation

with speculation. It is difficult to assess the importance of this finding given the relatively low t-value. However, the estimated sign gives weight to the hypothesis that speculation may be attracted to newly developed markets but subsides to some natural level as the market matures. In the early stages the need for plenty of speculation may be important as hedgers needs are not well established. Hence, the speculative attraction to new markets is beneficial in that hedging business is facilitated.

The performance of the spreading variable in a statistical sense is rather weak judging from the associated t-statistic. Nonetheless, a positive relationship between speculation and the spreading variable was estimated. Earlier it was argued that this relationship was nebulous, at least conceptually, and would have to be subjected to empirical analysis for additional clues. As the empirical results suggest there is very little information that would enable a resolution of this issue.

Related to the spreading variable in a theoretical sense is the effect of perishability. Although statistically the effect of perishability does not appear to be very strong, it does suggest that nonstorable commodity markets attract more speculation. This is contrary to the hypotheses made regarding the effect of perishability. If anything storability is expected to enhance speculation because of the spreading opportunities between futures of differing maturities. A possible explanation for this empirical anomaly is that the nonstorable commodity markets are relatively new which may elongate the period of sorting out hedgers needs.

Partial Effects of the Volume Equation

Spreading variable and volume

The spreading potential of a market enhances liquidity because of the infusion of better quality information. This hypothesis is supported by the estimated positive partial adjustment function which shows the response of volume over simulated values of the spreading variable (Figure 6.11). In this figure it is apparent that low spreading potential (e.g., SV < 50%) is associated with low volume levels. This says that markets with poor spreading opportunities will be less liquid than markets where intermarket activity is common.

It has been said that Kansas City and Minneapolis wheat futures markets depend heavily on spreading activity from Chicago [Working, 1954]. Since the potential hedging use of these markets is small, it is argued that these markets would succumb to inactivity if it were not for speculative infusion from Chicago. The simple correlation coefficients between the three wheat varieties priced at the respective aforementioned markets are relatively high exceeding 90 percent in all cases. At this level the impact of spreading opportunities on volume is pronounced as is readily evident in the figure below. The virtue of lower margin requirements and commissions on spread positions is that smaller markets can benefit from speculative spillover from markets that are more actively used.

Time trend and volume

Computer technology is argued to be an important factor on the cost side of futures market operations. In the last two decades technological advances in the computer industry and the communications would be expected to have a cost reducing effect on futures market operations. The

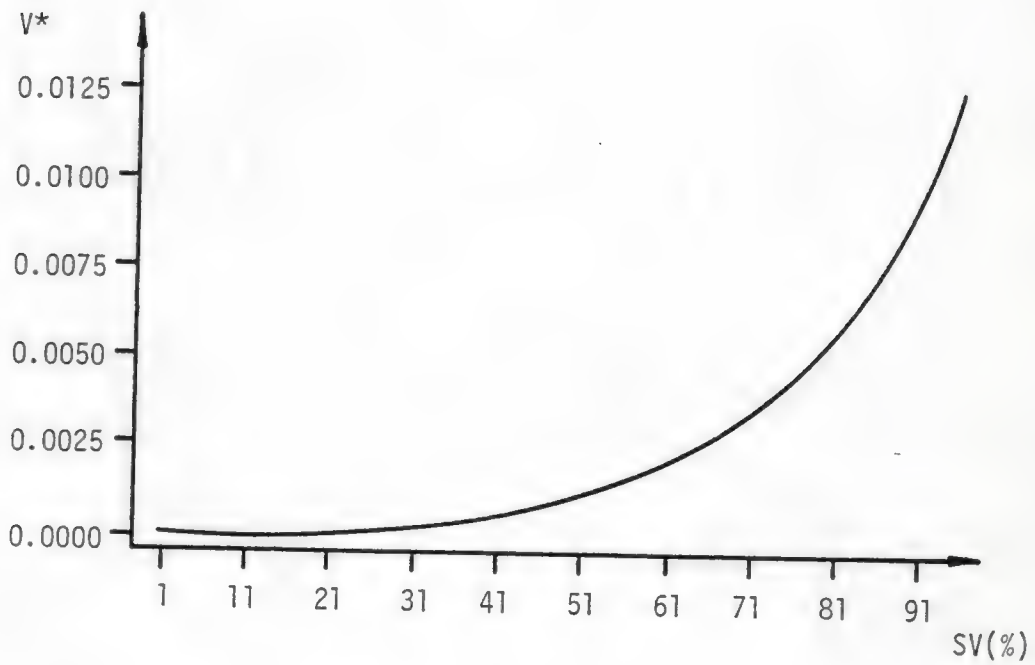


Figure 6.11--The simulated partial effects of spreading (SV)

time trend variable was utilized to capture this effect. As expected the estimated partial adjustment function shows volume to be positively related to the time trend variable. In Figure 6.12 shown below the temporal effect of improved technology as measured with the time variable has increased volume nearly threefold over the 1961-1978 period. Since the time trend variable is such a "catch-all," it may be picking up events in this period not associated with technological improvement. Events, such as the Vietnam war, the Arab oil embargo and the Russian grain deal, all of which could have affected futures market activity occured in this time period. Hence, the estimated partial effect may be confounded with additional information. Future research could be directed towards use of proxy variables which better capture the specific effects of technological improvement and other temporally varying effects.

Hedging and volume

Hedging activity was hypothesized to have a positive effect on volume for two reasons. One reason is the liquidity enhancement effect of spot-futures market arbitraging by hedgers. The other reason is that volume is created via the holding of open interest. It is obvious that the estimated coefficient is consistent with this view as seen in Tables 5.5 and 5.6. Moreover, this empirical evidence is further supported by a relatively high t-statistic.

A graph of the partial adjustment function showing the partial effects of hedging appears below (Figure 6.13). The unusual characteristic about this relationship is that one would expect the speculation variable to have a similar if not greater impact upon volume. In fact the speculation parameter carries the wrong sign and a corresponding low t-value as

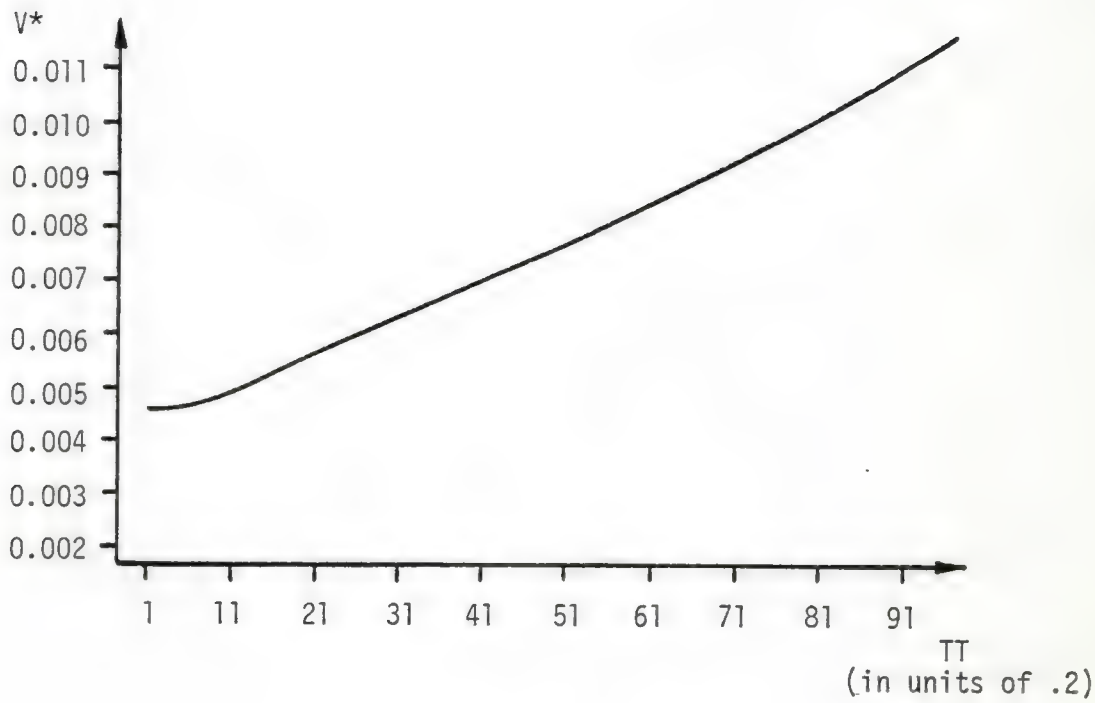


Figure 6.12--The simulated partial effects of the trend variable (TT)

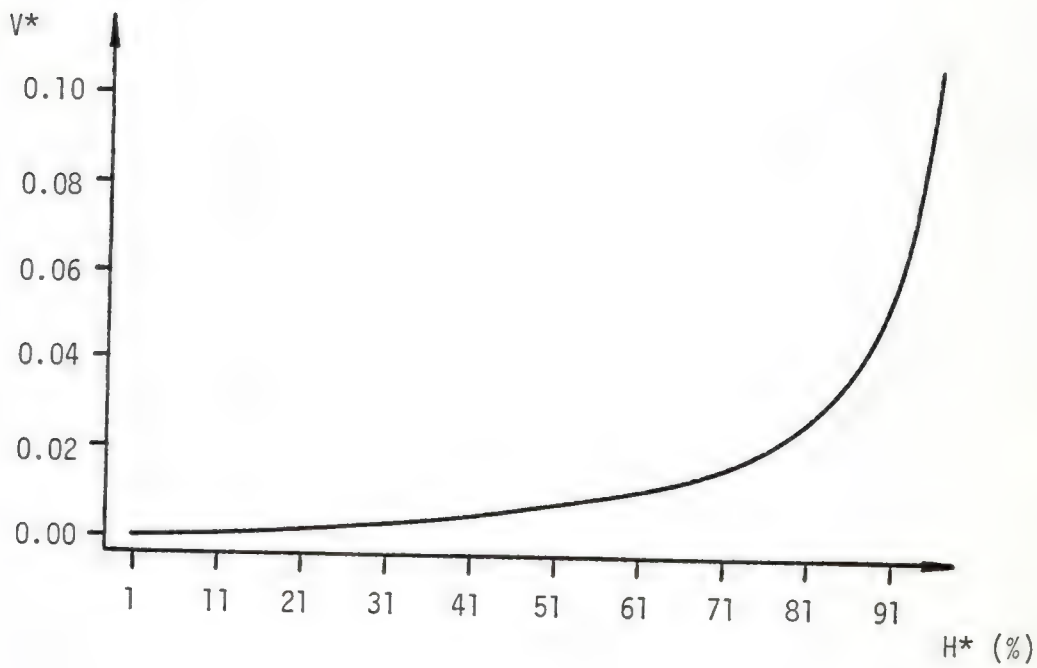


Figure 6.13--The simulated partial effects of hedging (H*)

mentioned earlier. This suggests that hedgers are more important in providing liquidity than are speculators, a notion that is contrary to the mainstream of thought. However, an argument setforth in this analysis, suggesting that speculative involvement is important but primarily in the early years of development, is a partial explanation of the observed results. A fuller investigation of the temporal aspects of speculative involvement in futures markets is warranted in light of the empirical findings.

Exchange rank, number of pits and volume

Since a futures market is typically housed on the floor of an exchange which can provide for trading for many such futures markets, futures markets are related. Specificially, the fixed and overhead cost of exchange operation is in a sense shared by the futures markets of the exchange. It was argued that exchange differences may lead to cost differences for the respective futures markets. Large exchanges (i.e., typified by many transactions) can spread these costs over more units of activity thereby reducing unit costs. An exchange rank variable was introduced to capture this effect. In figure 6.14 the partial adjustment function showing the effects of exchange rank is given. At an exchange rank of one, indicating the most voluminous exchange, volume is the greatest. This says that futures markets benefit in a cost sense by virtue of its association with a larger exchange. Alternatively, this result suggests the difficulty entailed in establishing a single market exchange if scale economies are present which is likely. However, this suggestion is somewhat weakened by the statistical weakness of the number of pits variable. This problem could result from the inadequacies of the proxy in measuring the scale effect. Improvement in the

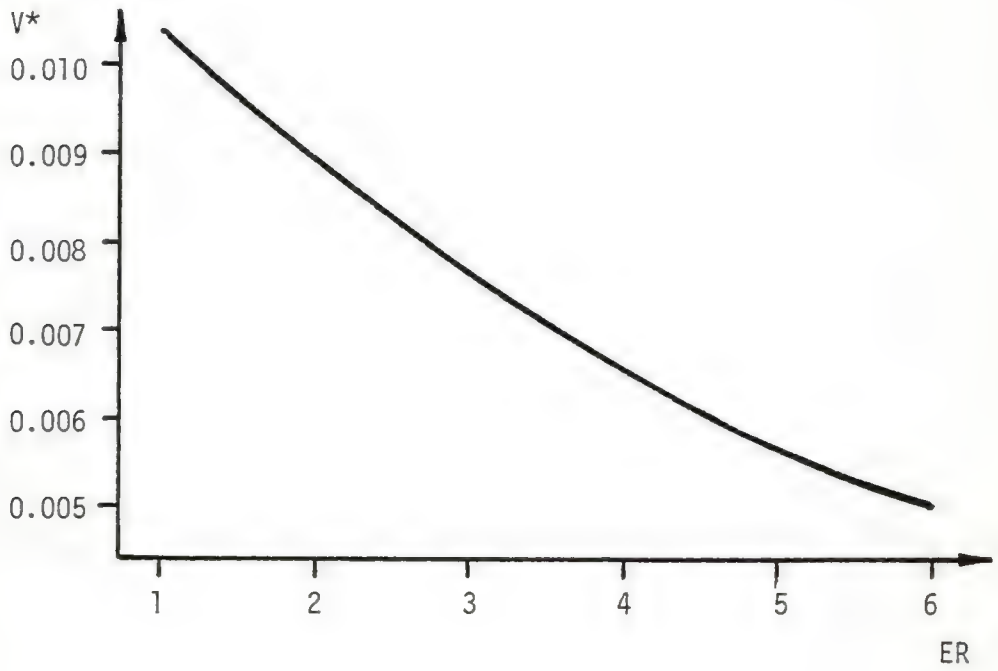


Figure 6.14--The simulated partial effects of exchange rank (ER)

operationalizing the scale effect of an exchange would be a desirable avenue of further research.

The Total Effects

The total effects of an exogenous shock to the futures market behavior model captures not only the partial effect, but also the interdependencies of the endogenous variables on one another. The effect of the endogenous variable interdependencies may reinforce the partial effect given an exogenous shock. On the other hand, it is conceivable that the total effect of a change in an exogenous variable on an endogenous variable could be opposite in sign to the partial effect. From a policy perspective it is not so important to know the partial effect if the total effect dominates the partial effect both in sign and in magnitude. Since the total effect measures the change in the equilibrium values of the endogenous variables given a shock to the system, exclusive attention to the partial effects may be misleading especially if there are significant differences between these two effects. In this section an investigation of the total effects will be undertaken.

Reduced Form Equations

The total effects discussed in Chapter 3 relate directly to the reduced form parameters of the estimated futures market behavioral model. Intuitively this makes sense because the reduced form equations are the solution to the structural equations in terms of hedging, speculation and volume. The resulting reduced form parameters are a weighting of the structural parameters. This weight depends on the relationship between the endogenous variables.

Consider the estimated model:

$$(6.3) \quad H = \hat{\beta}_{13} V + \sum_{i=0}^{14} \hat{\Gamma}_{1i} X_i$$

$$(6.4) \quad S = \hat{\beta}_{23} V + \sum_{i=0}^{14} \hat{\Gamma}_{2i} X_i$$

$$(6.5) \quad V = \hat{\beta}_{31} H + \hat{\beta}_{32} S + \sum_{i=0}^{14} \hat{\Gamma}_{3i} X_i$$

where $H = \text{Log}(\frac{1}{H^*} - 1)$,

H^* = hedging expressed in percent,

$S = \text{Log}(\frac{1}{S^*} - 1)$,

S^* = speculation expressed in percent,

$V = \text{Log}(\frac{1}{V^*} - 1)$,

V^* = volume expressed in percent,

$\hat{\beta}_{ij}$, $\hat{\Gamma}_{k\ell}$ = estimated parameters given in Tables 5.5 and 5.6,

X_i = variables corresponding to the specific exogenous variables in Table 5.5.

Alternatively, 6.3 through 6.5 can be rewritten as follows:

$$(6.6) \quad -H + \hat{\beta}_{13} V + \sum_{i=0}^{14} \hat{\Gamma}_{1i} X_i = -S + \hat{\beta}_{23} V + \sum_{i=0}^{14} \hat{\Gamma}_{2i} X_i = -V + \hat{\beta}_{31} H + \hat{\beta}_{32} S + \sum_{i=0}^{14} \hat{\Gamma}_{3i} X_i = 0$$

The system given by 6.6 is an explicit representation of the theoretical first order conditions presented in Chapter 3 (see eq. 3.6).

From equation 6.6 several points can be made regarding the underlying net benefit function. First the coefficients on the variables correspond to the total derivatives of the first order conditions developed in Chapter 3 (i.e., N_{HH}, N_{HS}, N_{SV}, etc.). Writing 6.6 in matrix notation yields

$$(6.7) \quad 0 = \begin{bmatrix} -1 & 0 & \hat{\beta}_{13} \\ 0 & -1 & \hat{\beta}_{23} \\ \hat{\beta}_{31} & \hat{\beta}_{32} & -1 \end{bmatrix} \begin{bmatrix} H \\ S \\ V \end{bmatrix} + \begin{bmatrix} \hat{\Gamma}_{10} \cdots \hat{\Gamma}_{1,14} \\ \hat{\Gamma}_{20} \cdots \hat{\Gamma}_{2,14} \\ \hat{\Gamma}_{30} \cdots \hat{\Gamma}_{3,14} \end{bmatrix} \begin{bmatrix} X_0 \\ \vdots \\ X_{14} \end{bmatrix}$$

Hence, the matrix of coefficients on the endogenous variables corresponds to equation 3.14. Writing this correspondence explicitly yields:

$$(6.8)\quad \begin{bmatrix} -1 & 0 & \hat{\beta}_{13} \\ 0 & -1 & \hat{\beta}_{23} \\ \hat{\beta}_{31} & \hat{\beta}_{32} & -1 \end{bmatrix} = \begin{bmatrix} N_{HH} & N_{HS} & N_{HV} \\ N_{SH} & N_{SS} & N_{SV} \\ N_{VH} & N_{VS} & N_{VV} \end{bmatrix}$$

The second order conditions of the net benefit function can be empirically evaluated. The principal minors of the matrix of the left of 6.8 alternate in sign which implies strict concavity. This is gratifying because it implies a stable equilibrium. Equilibrium values of H, S, and V can be found by solving 6.7 which yields the following:

$$(6.9)\quad \begin{bmatrix} H \\ S \\ V \end{bmatrix} = - \begin{bmatrix} -1 & 0 & \hat{\beta}_{13} \\ 0 & -1 & \hat{\beta}_{23} \\ \hat{\beta}_{31} & \hat{\beta}_{32} & -1 \end{bmatrix}^{-1} \cdot \begin{bmatrix} \hat{\Gamma}_{10} \cdots \hat{\Gamma}_{1,14} \\ \hat{\Gamma}_{20} \cdots \hat{\Gamma}_{2,14} \\ \hat{\Gamma}_{30} \cdots \hat{\Gamma}_{3,14} \end{bmatrix} \begin{bmatrix} X_0 \\ \cdot \\ X_{14} \end{bmatrix}$$

The coefficients on the X_i in 6.7 are the N_{HZ}, N_{SZ}, and N_{VZ} from 3.14. Since H, S, and V are linear functions of X_i, it should be apparent that the product of the coefficient matrices corresponds to the total effects given by 3.16, 3.17, and 3.18. The product of the coefficient matrices is also the derived reduced form parameters which are given in Table 6.6.

Total Derivatives of the Endogenous Variables

Intuitively, the derived reduced form parameters make sense. To see why this is true assume that $\frac{\partial V}{\partial S}$ equals zero (i.e., $\beta_{32} = 0$). This assumption says that speculation does not directly affect volume which was essentially what the structural parameter results suggest. In fact, statistically the speculation equation resembles a recursive relationship. In this case the total derivatives of the endogenous variables (i.e., H*, S*, and V*) with respect to one another are more easily derived:

$$(6.10)\quad \frac{dH^*}{dV^*} = \frac{\partial H}{\partial V}\left(1+\sum_{i=1}^{\infty}\left(\frac{\partial V}{\partial H}\ \frac{\partial H}{\partial V}\right)^i\right)\frac{H^*(1-H^*)}{V^*(1-V^*)} = \hat{\beta}_{13}(1-\hat{\beta}_{31}\hat{\beta}_{13})^{-1}\ \frac{H^*(1-H^*)}{V^*(1-V^*)}$$

$$(6.11)\quad \frac{dS^*}{dH^*} = \left(1+\sum_{i=1}^{\infty}\left(\frac{\partial V}{\partial H}\ \frac{\partial H}{\partial V}\right)^i\right) = (1-\hat{\beta}_{31}\hat{\beta}_{13})^{-1}$$

$$(6.12)\quad \frac{dS^*}{dV^*} = \frac{\partial S}{\partial V}\left(1+\sum_{i=1}^{\infty}\left(\frac{\partial V}{\partial H}\ \frac{\partial H}{\partial V}\right)^i\right)\frac{S^*(1-S^*)}{V^*(1-V^*)} = \hat{\beta}_{23}(1-\hat{\beta}_{31}\hat{\beta}_{13})\frac{S^*(1-S^*)}{V^*(1-V^*)}$$

$$(6.13)\quad \frac{dV^*}{dH^*} = \frac{\partial V}{\partial H}\left(1+\sum_{i=1}^{\infty}\left(\frac{\partial V}{\partial H}\ \frac{\partial H}{\partial V}\right)^i\right)\frac{V^*(1-V^*)}{H^*(1-H^*)} = \hat{\beta}_{31}(1-\hat{\beta}_{31}\hat{\beta}_{13})\frac{V^*(1-V^*)}{H^*(1-H^*)}$$

$$(6.14)\quad \frac{dV}{dS} = \frac{dH}{dS} = 0$$

The term $(1 - \frac{H}{V}\ \frac{V}{H})^{-1}$ is the result of a geometric progression which accounts for the hedging-volume simultaneity once the system has been shocked and asymtotically approaches a new equilibrium. Since a change in an exogenous variable amounts to a shock to the system, it is apparent that the total effects of the exogenous variables will be a function of $(1- \frac{\partial H}{\partial V}\ \frac{\partial V}{\partial H})^{-1}$.

Suppose an increase in the correlation coefficient occurs which leads to an increase in hedging (i.e., the partial effect). The increase in hedging leads to an increase in volume which leads to a further increase in hedging. Eventually the process dampens resulting in the attainment of a new equilibrium. In most cases the total effect strongly reinforces the partial effect as can be seen in Table 6.6. This is a consequence of the strong hedging-volume relationship. In the figure below the total and partial effects of concentration on hedging are shown indicating the reinforcement by the total effect (Figure 6.15).

The reinforcement of the partial effect can be further illustrated with the elasticity measure. The elasticity of hedging with respect to volume can be derived using 6.10. This elasticity, ε_{HV}, is equal to $\hat{\beta}_{13}(1- \hat{\beta}_{31}\hat{\beta}_{13})(\frac{1-H^*}{1-V^*})$. Assuming that the later term $(\frac{1-H^*}{1-V^*})$, is equal to

Table 6.6--Reduced form parameters based on third stage estimated using Scheme 1 (see equation 3.14)

Variables		Activity Equations					
		Hedging		Speculation		Volume	
	X_i	Reduced Form	Struct.	Reduced Form	Struct.	Reduced Form	Struct.
Concentration	X_1	-.178	-.064	-.131	0	-.141	0
Concentration Sq.	X_2	.0015	-.0005	.0011	0	.0012	0
Firm numbers	X_3	-.000037	-.000013	-.000027	0	-.000030	0
Correlation Coef.	X_4	-.817	-.294	-.601	0	-.649	0
Coef. of var.	X_5	.299	.111	.304	.098	.232	0
Coef. of var. sq.	X_6	-.0058	-.0021	-.0043	-.0017	-.0046	0
Loan rate	X_7	.996	.359	.773	0	.792	0
Perishability	X_8	2.17	.04	2.90	.45	2.65	1.00
Maturation	X_9	-.067	-.024	-.046	.0030	-.053	0
Stock yield	X_{10}	-.012	0	.091	.106	-.016	0
Spreading	X_{11}	.108	0	-.126	-.0017	-.135	-.051
Number of pits	X_{12}	-.004	0	-.004	0	-.0051	-.0019
Exchange rank	X_{13}	.314	0	.316	0	.391	.148
Time trend	X_{14}	-.085	0	-.098	0	-.106	-.040
Intercept	X_0	16.90	1.06	15.40	-2.83	19.71	6.43

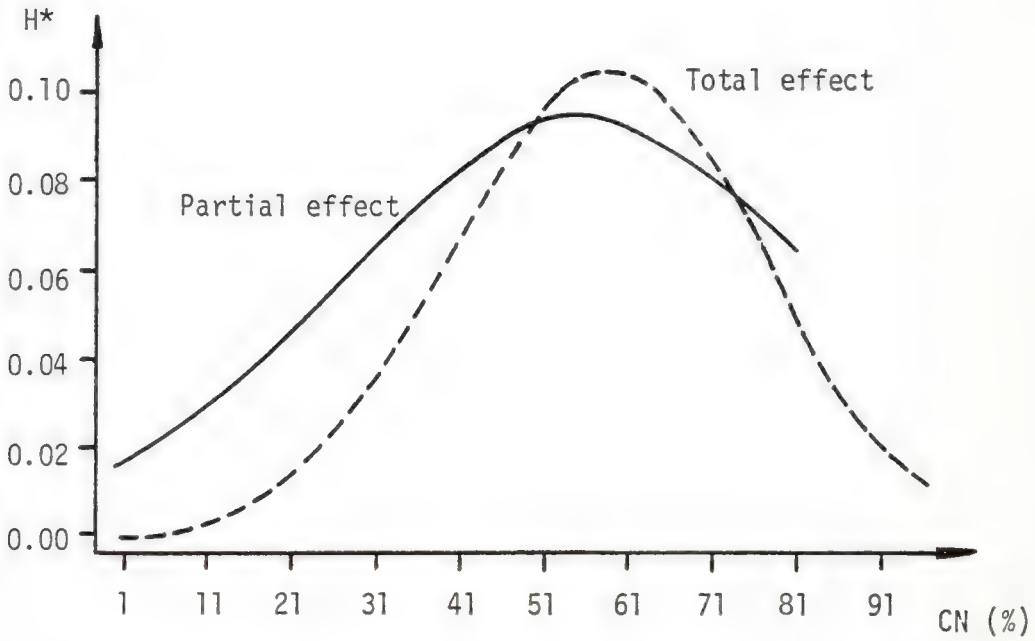


Figure 6.15--Relationship between the total and partial effect of concentration (CN)

one, ε_{HV} simplifies to $\hat{\beta}_{13}(1-\hat{\beta}_{31}\hat{\beta}_{13})$ which is approximately equal to a value of 2.41 when evaluated using the estimated values. The assumption of unity is within reason because observed values of H* and V* are typically smaller than ten percent (see Table 6.1). Hence a one percent increase in V* will lead to a 2.41 percent increase in H*. The rather large elasticity is additional evidence that supports the reinforcing characteristic of the total effects.

Potential Versus Actual Use

Up to this point the endogenous variables have been expressed as a percent of the total commodity supply. Some additional insights can be gleaned from looking at the model in terms of actual values of hedging, speculation and volume. The reduced form equations are rewritten as follows:

$$(6.15) \quad H^* = 1/(1 + \exp(\sum_{i=0}^{14} \hat{\pi}_{1i} X_i)),$$

$$(6.16) \quad S^* = 1/(1 + \exp(\sum_{i=0}^{14} \hat{\pi}_{2i} X_i)),$$

$$(6.17) \quad V^* = 1/(1 + \exp(\sum_{i=0}^{14} \hat{\pi}_{3i} X_i)),$$

where $\hat{\pi}_{ji}$ = reduced form parameters.

Recall that H*, S*, and V* are expressed as a percent of total supply (see equation 4.25). These terms are explicitly given by:

$$(6.18) \quad H^* = \frac{H^{**}}{TS}$$

$$(6.19) \quad S^* = \frac{S^{**}}{TS}$$

$$(6.20) \quad V^* = \frac{V^{**}}{TS}$$

where H** = actual hedging open interest,

S** = actual speculation open interest,

V** = actual volume,

TS = total supply.

Rewritting 6.15 - 6.17 yields the following:

$$(6.21) \quad H^{**} = TS/[1 + \exp(\sum_{i=0}^{14} \pi_{1i} X_i)]$$

$$(6.22) \quad S^{**} = TS/[1 + \exp(\sum_{i=0}^{14} \pi_{2i} X_i)]$$

$$(6.23) \quad V^{**} = TS/[1 + \exp(\sum_{i=0}^{14} \pi_{3i} X_i)]$$

Conceptually the variable TS measures the potential level of hedging activity. It has been suggested in the literature that markets with a greater hedging potential are more likely to develop and survive [Hieronymus, 1971 and Telser, 1977]. Equation 6.21 is drawn in the figure below (Figure 6.16). The slope of the estimated hedging-total supply relationship is some function of the reduced form estimates and the corresponding exogenous variables evaluated at their means. Not surprising is the fact that $\frac{\partial H^{**}}{\partial TS}$ is estimated to be 4.6 percent. This value corresponds to the sample mean of H* which was found to be 9.4 percent (see Table 6.1).

The hedging-total supply function is linear emanating from the origin in Figure 6.16. The 45° line indicates the actual hedging boundary over the range of total supply recalling that both hedging and supplies are expressed in the same contract units. Current economic conditions results in a function denoted by M^0. As TS increases from TS′ to TS′′, H** increases from H′ to H′′.

As conditions become more favorable for futures market activity the actual hedging function may shift out say from M° to M^1 or M^2. This may happen for many reasons some of which have been mentioned in this text. For instance, as the market matures a greater proportion of potential users will be expected to use the market.

From a policy perspective a reasonable goal is to increase market use by hedgers to its fullest potential. This would improve the

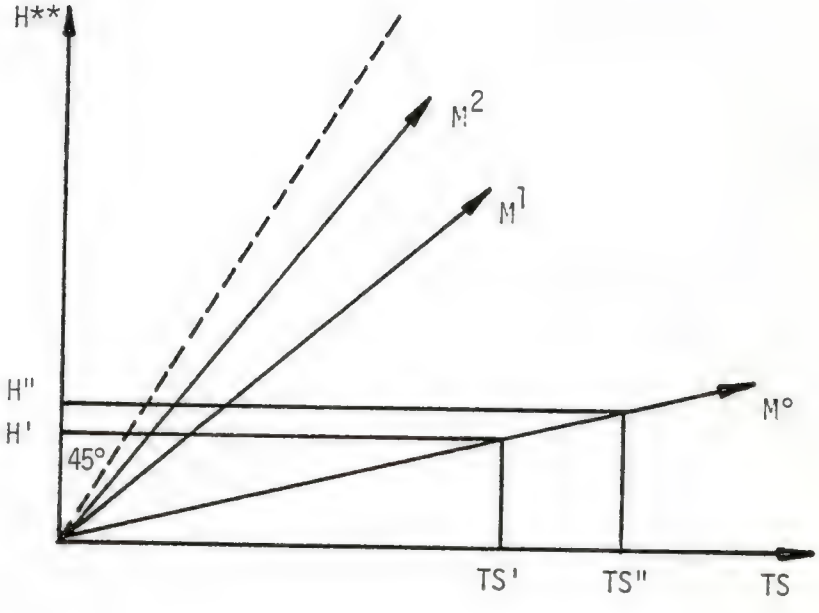


Figure 6.16--The relationship between total hedging open interest and total supply

efficiency of the futures price discovery process and the allocative as well as the forward pricing functions. Unfortunately, research to facilitate such efforts is hindered by the fact that potential hedging use is an unknown quantity. In this analysis total supply was used as a proxy despite the questions raised regarding its appropriateness. Further research could address this measurement problem which would enable a better understanding of potential hedging use. The relationship illustrated with Figure 6.16 is drawn without identifying a specific set of exogenous variables. Given such values, then the line corresponding to M could be drawn for a particular case. The potential use of a new or old futures market could be evaluated assuming various rates of industry growth over time. This procedure provides a convenient and informative way for assessing the level.

There are several final points to be made regarding the total effects. Notice that the coefficient signs of most of the variables across equations are identical. This happens because of the strong causal linkage between volume and hedging while speculation enters the model in essentially a recursive manner. The recursive nature of speculation is also indicated by the similarity between the structural and reduced form parameter on the utility yield (UY) variable in the speculation equation. Since speculation does not influence hedging or volume and UY does not appear in the other structural equations, the parameter should be identical. The discrepancy arises because the speculation parameter in the volume equation carries a very small negative value despite the statistical insignificance. This occurance also led to negative signs on the UY reduced form parameters in the hedging and volume equations. Although the total effects are important in that they show the adjustments from

equilibria to equilibria when the system is shocked, some of the reported reduced form or total effect parameters are based on statistically weak structural parameter estimates. Perishability and the number of pits are good examples of this phenomena. Hence, some of the total effects can not be considered meaningful.

Speculative Index

A speculative index was calculated to show the effects on the trader composition when the system is shocked by an exogenous change. The speculative index is calculated as follows:

$$(6.24) \quad SI = \frac{H^{**}}{S^{**}}$$

A change in, say, concentration will affect SI through its direct and indirect impact on H** and S**. From the reduced form parameters for example, it can be shown that concentration will have a stronger impact on hedging than it will on speculation. The respective elasticities with respect to concentration are given by:

$$(6.25) \quad \varepsilon_{HCN} = -(-.178 + .0030CN) \cdot CN \cdot (1 - H^*)$$

$$(6.26) \quad \varepsilon_{SCN} = -(-.131 + .0022CN) \cdot CN \cdot (1 - S^*)$$

Comparing the elasticities yields the relationship in equation 6.27:

$$(6.27) \quad .178 - .0030CN \gtrless (.131 - .0022CN)\frac{(1 - S^*)}{(1 - H^*)}$$

Assuming that $\frac{(1 - S^*)}{(1 - H^*)}$ equals unity, which is reasonable based on observed values of H* and S*, 6.27 simplifies to:

$$(6.28) \quad CN \lessgtr 58$$

This says that at concentration levels less than 58 percent $\varepsilon_{HCN} > \varepsilon_{SCN}$, whereas at levels greater than 58 percent $\varepsilon_{HCN} < \varepsilon_{SCN}$. Since 58 percent

corresponds to the maximum of the total adjustment functions for hedging and speculation, respectively, this result suggest that the ratio of the respective adjustments should resemble the hedging relationship. In Figure 6.17 and Figure 6.18 these relationships are drawn. The effect of the speculation adjustment on hedging is a weighting which has the effect of making the ratio adjustment less steep.

The model results suggest that the speculative index will respond to exogenous shocks in much the same manner as hedging. This follows because of the recursive nature of the speculation equation. Since hedging can affect speculation only through volume, variables that directly affect hedging, such as concentration, but not speculation will have a muted impact on speculation. Conversely, variables which directly affect speculation but not hedging will have virtually no impact on hedging because of the recursive nature of the speculation equation.

Similarly constructed speculative indicies have been considered as a gauge for measuring market liquidity. In terms of SI a relatively low SI is indicative of a liquid market because the proportion of speculation to hedging is great. Hence, hedging needs are easily accommodated. The results of this analysis imply that hedging activity is more important in enhancing liquidity, however. In Figure 6.19 the speculative index is plotted against corresponding volume levels as the age of a market is simulated. The adjustment, which is also presented in tabular form, suggests that both volume and the speculative index have a positive response to the age of a market (Table 6.7). A plot of the volume and the speculative index coordinates reveals that the index is positively related to volume which is the measure of market liquidity in this analysis. Thus, this is further evidence that the importance of speculation in liquidity enhancement is overstated.

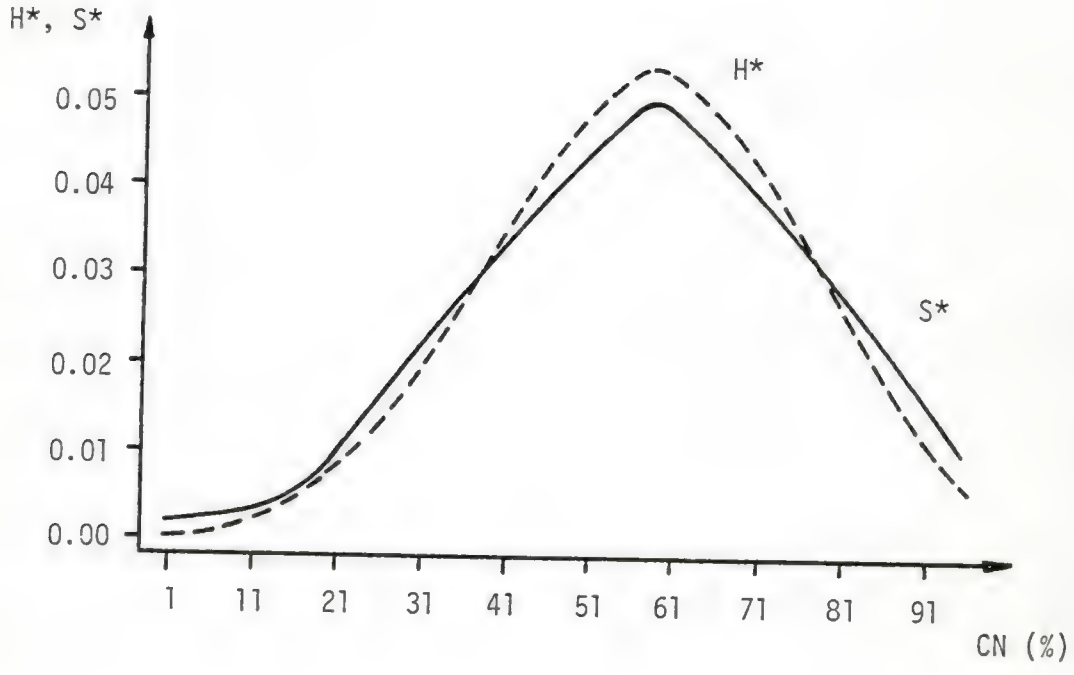


Figure 6.17--The total effect of concentration on hedging and speculation, respectively

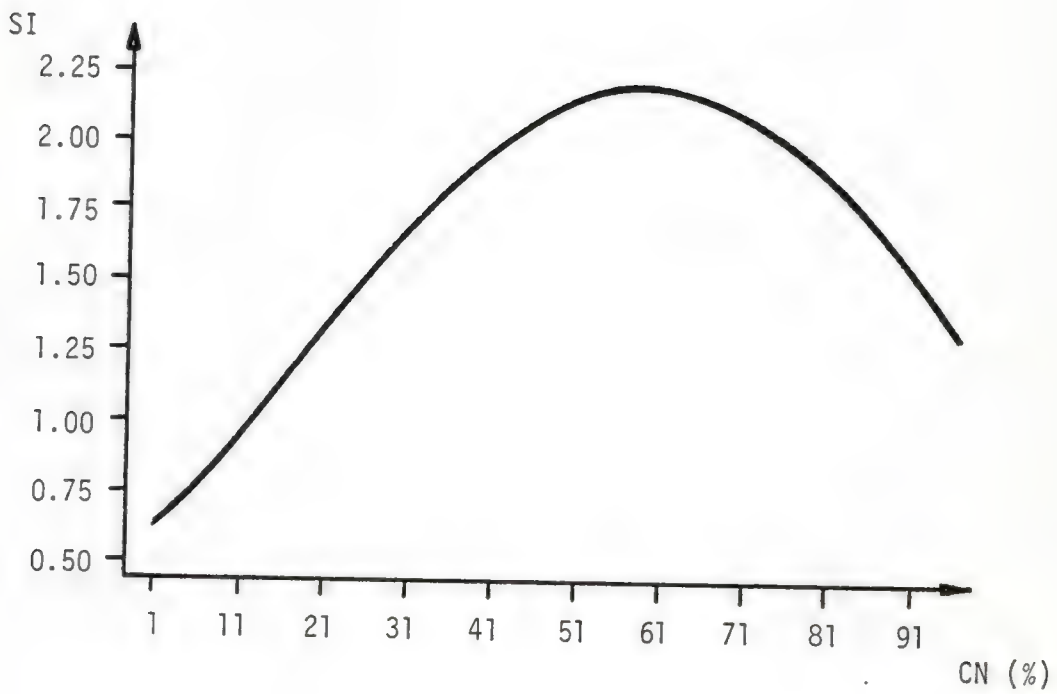


Figure 6.18--The effect of concentration on the speculative index

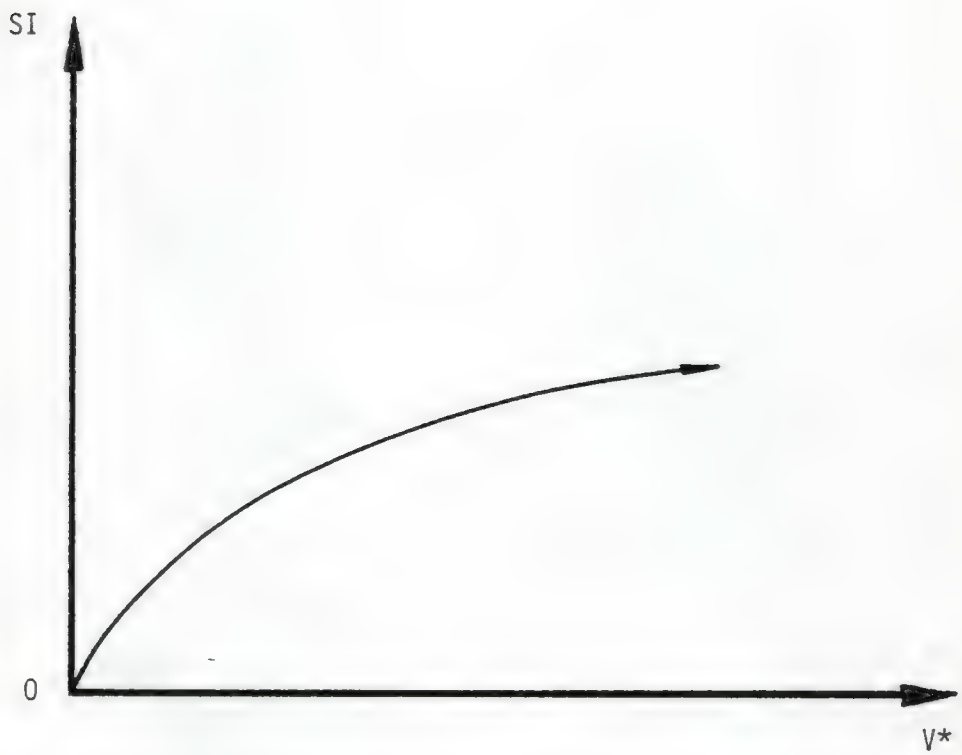


Figure 6.19--Plot of the speculative index and volume coordinates derived from a simulation of market age

Table 6.7--Total adjustment of the speculative index and volume as age varies

Age	Speculative Index	Volume
5	.678	.00053
15	.834	.00090
25	1.025	.00155
35	1.259	.00266
45	1.538	.00454
55	1.864	.00776
65	2.221	.04321
75	2.565	.02241
85	2.813	.03777
95	2.867	.06297

Summary

In chapter 6 an in-depth analysis of the econometric results was conducted. The analysis was by no means exhaustive suggesting research problems that deserve further inquiry. Nonetheless, several major conclusions highlight this research. One of these conclusions is the measurement of a statistical linkage between concentration and futures market activity. Together with the statistical importance of firm numbers, this finding suggests the causal linkage between futures market activity and market structure. Likewise, the effect of government influence on futures market activity was evidenced through the empirical results that support prices affect hedging activity. In the next and final chapter

these observations will be put into a broader perspective as this research will be summarized, and implications will be setforth.

CHAPTER 7

SUMMARY AND CONCLUSIONS

Futures Trading Overview

A major objective of this research was to develop a conceptual model showing the effects of market structure on futures market activity. Futures market activity was defined in terms of hedging and speculative open interest as well as the level of volume. Futures market activity may vary from market to market because of differences in market structure and other influential factors. For instance, differences in supply and demand elasticities across commodity markets can give rise to cross-sectional differences in the exposure to price risk. These differences are expected to influence hedging and speculative behavior which is sensitive to the degree of price risk.

A futures market was argued to be an institution serving the commodity complex that evolved in response to hedgers needs. Futures markets have evolved from forward trading, primarily via forward contracting, in most cases. Transactions, which are made for future delivery, facilitate the shifting of risks, assure a market outlet and can establish profit margins in the current period. A futures market is a means whereby commercial interests can make forward transactions. The benefit of using a futures market is the liquid conditions which prevail in well-functioning markets. Liquid conditions tend to keep the transactions cost of futures to a minimum which is important to both hedgers and speculators.

It was argued that the level of volume is positively related to the level of liquidity present in a market. If markets fail to generate sufficient liquidity (i.e., volume) they lose their basis for existence and will more than likely die from lack of use. Hedging, speculation and volume levels are endogenously determined. Ultimately the levels of these variables depend on the structural, legal and institutional setting which defines the boundaries for the economic activity of a commodity.

A net benefit model was proposed as a conceptual model of futures market behavior. Net benefits are some function of hedging, speculation and volume levels. A futures market is optimizing if the level of its activity maximizes the net benefit function. The levels of hedging, speculation and volume which maximize the net benefit function are also optimal.

Exogenous differences in market structure and other factors lead to differences in the optimal levels of hedging, speculation, and volume. Market power, which is a phenomena becoming more evident in the agriculture sector, is one structural characteristic that was cited as having an influence on futures market activity. Specifically, it was argued that atomistically organized industries may have difficulty supporting a futures market because firms may be too small to specialize in the use of futures markets. Larger firms can support a bevy of traders and a research staff which would enhance futures trading activities. However, a highly oligopolistic structure may cause pricing problems in futures markets as the possibility of a squeeze is more imminent. The later structure diminishes the possibility for the existence of a futures market. Other structural characteristics considered in the analysis were firm numbers and potential use.

Another important exogenous influence considered was the degree of price risk. Great price uncertainty raises the benefits of futures markets to hedgers and speculators because it facilitates a flexible means to deal with price uncertainty. On the other hand price uncertainty has an impact on the cost of exchange operations as the risk of contract default is borne by exchange members trading for their clientel. Margin requirements are required as a security deposit against the possibility of default risk. Margin requirements represent a cost to hedgers and speculators, and accordingly should affect trading activities. The net effect of price risk was an issue addressed empirically and a direct relationship between hedging and speculation to price risk was shown.

Basis risk was also argued to be an important factor which could affect hedging behavior because it relates to the hedging effectiveness of a futures contract. Other variables which were argued to directly affect hedging activity in the futures market included government price support activities, market maturity, the degree of commodity perishability and the level of volume. Since the level of volume is a measure of liquidity, volume increases reduced hedger transactions costs resulting in an increased level of hedging activity.

Speculative opportunity cost, spreading potential, and volume were cited as factors which would give rise to differences in speculative behavior across markets as well as intertemporally. Speculative opportunities in, say, the stock and bond markets are expected to draw speculative dollars out of futures positions if the opportunity cost is sufficiently great. The empirical evidence clearly supported this hypothesis. Spreading increases the speculative opportunities across

markets, but it may reduce the speculative dollars present in a single market. The net effect of spreading was addressed as an empirical question. Like hedging, volume was argued to have a beneficial effect on speculation because it enhances liquidity thereby lowering transactions costs.

Spreading opportunities also were hypothesized to enhance liquidity because spreading or arbitraging activities infuse better quality information into the price discovery process. Since spreading opportunities increase liquidity the effect of spreading opportunities on volume is positive. The costs of exchange operation may vary across exchanges which would affect the cost of futures market operations. Economies of scale and technological improvement were argued to be influential with regard to the cost of processing trades. Hedging and speculation were hypothesized to have a positive effect on volume because of their respective impact on liquidity. Also, hedging and speculative open interest are technically related to volume.

The conceptual model was used as a foundation in the construction of an econometric model which was built and estimated to test the theoretical hypotheses. In building the econometric model several problems were encountered. By far the most serious problem relates to the data. Since a significant proportion of the open commitments are classified as nonreporting, a systematic procedure was used to allocate the open interest between hedging and speculation. Any procedure used is likely biased unless one wishes to survey all of the nonreporting traders. Hence, a shortcoming of the model is the measurement error present in the hedging and speculation variables. The use of proxy variables in some cases leads one to question whether the proxy is

capturing the desired effect. In the case of market power a proxy, which measures the 4-firm concentration ratio of the industry which dominates trading in a futures market, was used. Whether this variable actually measures the effects of market power is an empirical question. Likewise, the coefficient of variation and the correlation coefficient are proxies for cash price risk and basis risk. Although the empirical approach to these risk variables is consistent with the literature, further research may require a more rigorous theoretical underpinning for empirical use.

Without question there is difficulty in going from a theoretical model to an empirical approximation. Concentration and the coefficient of variation are two such approximations which were adopted so that an empirical investigation could be implemented. Similar problems, which were discussed in the text, exist with the firm numbers variable, the total supply variable and the spreading variable. Moreover the absence of literature dealing with the structural effects on futures market activity suggests the strong possibility that influential structural effects may have been overlooked by this researcher. In other words there may exist exogenous influences which should be included in the model but are excluded. One influence that arguably could be included in the model is the presence of competing means of forward exchange in a commodity complex. For instance, the presence of forward contracting, vertical integration and marketing cooperatives are alternative structural arrangements which facilitate forward exchange. These structures could undoubtedly affect the hedging use of a futures market. However, time and data limitations restricted the investigation to the model presented.

To conduct the empirical work data on 16 agricultural commodity futures markets were used. The sample period covered the years 1961-1978. A simultaneous equation econometric model was developed to obtain empirical estimates of the parameters that are derived from the theoretical net benefit function. The endogenous variables of the model are the observed hedging, speculation and volume levels. Since there was a problem with regard to scaling and the units of measure, these variables were adjusted by the corresponding total supply. Although the equations of the model were specified to be intrinsically nonlinear, nonlinearities were built into the model with the use of the logistic functional form. The properties of the logistic function corresponded to the hypothesized relationships between the endogenous variables and exogenous variables which makes the logistic specification appealing. Fourteen exogenous variables were included in the model as explanatory variables. Each of these variables has a theoretical counterpart. Hence, the coefficients of these variables relate to the theoretical hypotheses.

Several problems were encountered in the estimation procedure. Each of the three equations was found to be overidentified which suggests that OLS estimation of this equation would be inappropriate on the basis of the consistency criteria. In addition, since the data is pooled cross section and time series direct OLS estimation ignores information specific to each cross section. Ignoring this information implies a loss of efficiency. Also the disturbances of the equations of the model are contemporaneously correlated. This happens for several reasons, one of which is the problem of measurement error in hedging and speculation.

An estimator was developed to deal with the aforementioned problems. The estimation procedure was divided into three stages. In the first

stage the endogenous regressors were replaced by their respective predicted values. Then a ML technique was used to obtain second stage estimates of each structural equation. Since each equation can have a different cross-sectional influence, a variance-components model was estimated separately for each equation using a ML estimator. Using the residuals corresponding to the ML second stage estimates, the variance-covariance matrix for the equation disturbances was estimated. To complete the third stage the estimated variance-covariance matrix was incorporated into a Generalized Least Square (GLS) estimator and the final estimates were obtained.

Futures Model Conclusions

The results of the empirical analysis contain a number of important findings as well as anomolies deserving further inquiry. It was observed that concentration had a significant impact on hedging. That is at low concentration levels the marginal effect is positive which implies small firms do not make extensive use of futures markets. However, at concentration ratios greater than 58 percent the marginal effect of concentration on hedging is negative reflecting the noncompetitive effects of movement toward oligopolistic structures. Another structural characteristic, firm numbers, was shown to affect the level of hedging in a significant manner. These particular effects indicate that the structure, within which the economic activity of a commodity transpires, has a causal influence on futures market activity. Research dealing with long run problems associated with futures market activity must recognize this evidence since structure can not be assumed away. Also, public policy directed at structural problems may unwittingly affect

futures market activity. Hence, this kind of evidence could enhance decision making which goes into policy dealing with structural issues.

Aside from the observed market structure-futures market linkage, the results suggest that government activity in commodity markets via price support activities will also affect futures market activity. This is not so surprising because government price support activities have the effect of shifting price risk from the agriculturalists to the public sector. Since futures markets facilitate the shifting of risk from hedgers to speculators, government price support policy is seen as an alternative means to deal with price and income uncertainty.

The problem arising with price supports is the fact that futures market activity will eventually succumb if prices are effectively supported for any length of time. This happens because price uncertainty is eliminated through publicly prescribed demand-side intervention, obviating the need for a futures market. Futures markets, on the other hand, do not affect price uncertainty resulting from the vagaries of supply and demand. Rather, the futures market facilitates risk shifting without affecting the uncertain nature of supply and demand. Hence, resource allocation is market determined. Whether this is a preferred alternative is open to public debate.

There is some concern that the presence of futures markets may have an adverse effect on the cash price discovery process leading to increased price volatility. In the current research the causal relationship between futures market activity and price risk was assumed to be unidirectional. The empirical results suggest that hedging and speculative activity respond to price variability. The investigation of a two-directional causal linkage is left for further research.

A finding of the analysis which deserves further scrutinity is the quadratic effect of price risk on hedging and speculative behavior. It was observed that at low levels of price variability the marginal effect on hedging and speculation was negative. This owes to the fact that the cost of futures market operations appears to be more responsive to price variability than does user benefits. However, at higher levels of price variability the benefits of using a liquid market dominate the cost effects at the margin resulting in a positive hedging and speculative response to price variability. One interesting result relating to this relationship was that price variability had a limited numerical effect on hedging and speculation in the range of values within the data set. This suggests that price variability may not be as important as once thought in affecting hedging and speculative behavior, assuming prices continue to vary within the same range of values.

The importance of liquidity in attracting hedging and speculative behavior was given further empirical support in the preceding analysis. Using volume as a measure of liquidity, it was observed that both hedging and speculation responded significantly to changes in the level of volume. It was shown that the elasticities of hedging and speculation with respect to volume were greater than unity. Although the estimated effect of liquidity is as expected, the importance of speculation in creating liquidity is not. The results suggest that the need for speculation in futures markets is questionable. However, a strong argument was set-forth indicating the importance of speculation in the developing years of a futures market.

Since it may take a few years to sort out hedging needs, a certain level of speculation may be required to ensure the necessary level of

liquidity. As the market matures the need for speculation is lessened reflecting more systematic hedging use. However, the results also show that hedging use may take a very long time to mature possibly as much as 100 years implying that understanding hedging needs may take a long time. Public and private efforts to improve the understanding of futures markets by its potential users would be a fruitful endeavor as indicated by the results. This kind of support could enhance the pricing and allocative functions of futures markets if broader use ensued. Liquidity would also be improved because the quality of information present in the pricing process would be improved.

A summary of the other findings is listed below:

1.) Hedging activity responds to the level of basis risk in a market. Hedging was found to be positively related to the cash-futures price correlation coefficient. This implies that markets with greater basis risk will attract less hedging activity.

2.) Perishability was not found to be a major empirical factor in affecting futures market activity. Although it is questionable whether a highly perishable commodity could support a futures market, the results do suggest that at least for semi-perishables such as live cattle, the perishability characteristic does not directly make a major difference in the level of trading activity. However, perishability is important when the indirect effects are considered via the complete system as estimated.

3.) Speculation will respond to other investment opportunities. This evidence was supported by the estimated inverse relationship between speculative activity and the yield on utility stocks traded on the New York Stock Exchange.

4.) A time trend variable was found to be significant in its effect on volume. It suggests that technological improvement in the production of transactions has substantially reduced the cost of processing trades and the attendant exchange services, such as information dissemination. This has increased the level of volume which has the beneficial effect of enhancing market liquidity.

Importance of the Research

Futures trading literature has increased substantially in the last decade. Much of this information is devoted to the development of trading plans and speculative strategies. Research related to the performance of specific futures markets is frequently published in both technical journals and popular magazines. Finally, many of the legal issues are cited in both economic and regulation literature.

All of these numerous sources of information are essential ingredients to understanding the futures industry, each providing some additional evidence about the market. However, the results are frequently commodity specific and not cumulative in the sense of making general performance statements about all futures markets.

At the outset, this study is important in that the conclusions are general across futures markets. Yet conclusions can be related to specific industries if the appropriate values for the exogenous variables are identified. Using the empirical results from the third stage and reduced forms, the models provide insight into the following general areas listed below:

(1) structural effects; (2) price risk; (3) government price support policies; (4) futures-cash market price performance; (5) storability effects; (6) market size; (7) liquidity needs and speculation;

(8) aging and market maturity; (9) inflation; and (10) market uniqueness of commitments. Given these areas the importance and usefulness of this research can be related to potential users. These users are briefly discussed in the following sections. These sections are not intended to be exhaustive. Rather they should provide the reader with some understanding of the range of potential uses of the research.

Federal Regulatory Agencies

CFTC is the primary agency responsible for overseeing the functioning of all commodity futures. Questions specifically related to evaluation of the market use are raised at this level. The models developed in the research can be used to evaluate questions of excess speculation, importance of liquidity, and the impact of structural change. Assessment of the reasons for high or low trading activity can be related to the exogenous variables in the model in order to help explain why the wide differences in success of markets prevail.

Furthermore, the analysis points to the importance and problems in dealing with commitment data. Alternative allocation schemes for non-reported commitments were developed and the impacts of each scheme on the empirical models were setforth. These schemes should prove to be of some methodological importance to the agency.

USDA

The U.S. Department of Agriculture has primary responsibility for evaluating the impact of numerous federal policies on various industries. While the impact of most price support policies are much broader than just its effect on futures, this econometric modeling provides additional sources for evaluating the impact of price controls on the futures institutions.

Furthermore, this work should complement the ongoing economic research on futures trading found within the USDA.

Futures Exchanges

Futures exchanges are generally preoccupied with the operations of existing markets and the development of new futures contracts. Trading volume is important to the success of any futures market and the parameters of this research can be used to show the impact of changing volume.

Expectations about future uses of various existing markets can be made via looking at changing in industry size, impact of inflation via alternative investment opportunities, etc. Evaluations of the potential trading levels for proposed new contracts can be enhanced with these models. Questions about the levels of trading in storable versus non-storables can be addressed by exchanges with the use of these models.

Industry and Trade Associations

The role and importance of futures markets are often raised at the industry level. The results from the futures trading model can be useful for showing how futures markets are expected to perform for particular industries. The importance of speculation and liquidity, which is often debated and misunderstood within many industries, can be illustrated. Also, the expected usefulness of a contract to a particular industry can be shown under a wide range of economic conditions. Changes in the use of futures among industries where considerable structural change has occurred can be demonstrated.

Brokers, Firms and Producers

The results provide very little insight into how to actually use the market. Hence, most benefits to actual traders would arise out of

the indirect effects from policies changes influencing futures markets. One can argue, however, that understanding the operations of futures markets at a macro level provides insights into a greater understanding and use at a micro level. Hence, given appropriate dissemination of parts of the information embedded in this effort, the research should complement individual users in their struggles to understand and remove the mystique often associated with futures trading.

Academic Research

Much of the theoretical and empirical research in the field of futures trading occurs at the academic level. This research should add to the body of literature on futures trading. Methods for pooling cross sections of futures contracts over time within a simultaneous system are new to the futures literature. Likewise, questions of structural effects, government programs, etc. and their impact on trading are first addressed in this study.

General Conclusions

Futures markets are institutional arrangements which evolve to meet the forward needs of commercial interests. Users, namely hedgers and speculators, benefit from the use of a futures market because of the low cost of transacting brought about by highly liquid conditions. Use levels of futures markets may vary cross-sectionally as well as through time. This happens because of differences in potential use, market structure, the degree of price uncertainty, government involvement in commodity markets, market maturity, liquidity and other reasons. In this research an attempt was made to measure these effects. An important finding of the empirical analysis was that the degree of concentration,

which is a measure of market power, explained differences in futures market activity. The results suggest that long run analysis of futures markets must recognize the dynamic structural, legal and institutional setting within which the futures market evolves.

Data problems were encountered in operationalizing the conceptual model which clouds the empirical analysis. Also, the causal linkage between futures market activity and market power may be two-directional rather than uni-directional as assumed in this analysis. These problems could serve as the focus for further research. Nonetheless, the relationship of futures market to its environment has policy implications ranging from anti-trust to price support policy. Trading activity and ultimately the existence of futures markets may depend on the degree of market power and/or government involvement in commodity markets. Futures markets perform important pricing and allocative functions not to mention the benefits to users. In this research it has been shown that the futures market is not independent of the commodity complex, but rather it is an important component.

APPENDIX A

A LIST OF THE MARKETS

In Table A.1 a list of the commodity futures markets used in the analysis is given. The markets are listed by an identification number (ID). Also, the exchange which houses the respective futures markets are shown.

Table A.1--A list of the markets used in the empirical analysis

ID	Futures Market	Exchange
1	Wheat	CBOT
2	Wheat	KCBT
3	Wheat	MGE
4	Corn	CBOT
5	Oats	CBOT
6	Soybeans	CBOT
7	Soybean Oil	CBOT
8	Soybean Meal	CBOT
9	Potatoes	NYME
10	Hogs	CME
11	Pork bellies	CME
12	Live cattle	CME
13	Feeder cattle	CME
14	Eggs	CME
15	FCOJ	COT
16	Cotton	COT

In Table A.2 a list of the variables used in the analysis and their corresponding symbol is given.

Table A.2--A list of the variables used in the empirical analysis

Symbol	Variable
CN	Concentration
CN^2	Concentration squared
FN	Firm mumbers
CC	Correlation of coefficient
CV	Coefficient of variation
CV^2	Coef. of variation squared
LN	Loan rate
PE	Perishability dummy
AG	Age
UY	Utility yield
SV	Spreading
NP	Number of pits
ER	Exchange rank
TT	Time trend

APPENDIX B

DATA SOURCES

Commitment data were obtained from the USDA-CEA annual summaries of trader commitments for the years 1961-1973. The data for the remaining years were collected from CFTC [1978] report of open interest statistics. Market age was also found in this source. Volume data for the 1961-1973 period were also obtained from the USDA-CEA summaries. The balance of the volume data came from statistics published by the Futures Industry Association and the Association of Commodity Exchange Firms, Inc. Exchange volume and pit data were obtained from these sources. Total supply data were tabulated from the Commodity Year Book published annually by the Commodity Research Bureau, Inc. In some cases the total supply data were supplemented with statistics obtained from the annual summaries published by the Chicago Mercantile Exchange.

Cash price data used in calculating the coefficient of variation were obtained from the various issues of the Commodity Year Book. Price support data were also recorded from this source. Futures price data for the years 1961-1972 were obtained from the USDA-CEA annual summaries. The Wall Street Journal was used for the remaining futures price observations. Utility yield observations were obtained from various issues of the survey of Current Business. Finally the concentration ratio and firm number data were collected from the Bureau of the Census of the U.S. Department of Commerce.

APPENDIX C

THE DATA

The following tables contain the data which was used in the econometric analysis. Sixteen tables corresponding to each market in the cross-section are presented. Time series observations on each market are given in the appropriate table. Table C.17 gives the variable and the corresponding symbols used in Tables C.1 through C.16.

TABLE C.1 COMMODITY TIME SERIES DATA

T=WHEAT(CHICAGO)

YR	HHH	SSS	SH	LH	SS	LS	NR	TR
1961	17308.5	13567.5	7466.2	2777.4	3830.8	4447.6	12774.4	18522.0
1962	27380.6	28124.6	12681.4	3009.8	7376.8	8740.8	23696.4	31808.8
1963	22418.7	25878.5	10515.4	1709.6	6171.8	7939.8	21960.6	26336.6
1964	17405.3	23452.3	7922.0	2168.2	5656.6	7939.2	17171.6	23686.0
1965	20534.9	18700.7	9704.6	2052.6	5104.4	5602.6	16771.4	22464.2
1966	25205.5	23710.1	12298.8	1826.4	5253.4	7993.6	21503.8	27412.2
1967	30063.6	36176.0	13310.6	3219.2	9756.4	10134.2	29819.2	36420.4
1968	29734.2	42242.6	14053.2	4322.6	12983.6	13122.4	27495.0	44481.8
1969	25881.0	41590.2	12682.0	3865.2	12871.2	13719.8	24333.0	43138.2
1970	18331.4	20671.0	7113.4	4830.2	6088.2	7379.8	13590.8	25411.6
1971	19192.3	13376.9	7274.6	4415.6	3920.6	4227.4	12731.0	19838.2
1972	17098.8	10610.0	4463.8	5507.4	2989.2	3198.0	11550.4	16158.4
1973	28078.1	13856.3	9270.8	8947.2	4012.2	5004.2	14740.0	27234.4
1974	35463.6	15452.4	11378.4	12746.8	5248.8	5263.2	16278.8	34637.2
1975	43160.3	15274.9	15071.6	15701.6	6023.6	4867.4	16771.0	41664.2
1976	55061.0	24045.6	22587.6	16553.4	8353.6	8739.6	22872.4	56234.2
1977	60965.3	27715.7	27458.8	18629.0	10117.8	10834.4	21641.0	67040.0
1978	55352.1	29612.5	21389.2	14909.8	8938.4	10481.0	29246.2	55718.4

YR	V	TS	HH	ST	VV	CN	FN	CC	CV
1961	391420	535200	3.39857	3.61796	5.83139	39	587	0.909170	4.5287
1962	682825	529800	2.90960	2.88131	5.26255	40	549	0.879824	4.1297
1963	872126	483600	3.02433	2.87329	4.92496	40	510	0.886927	2.5710
1964	904043	469200	3.25645	2.94478	4.85788	39	492	0.989633	10.2757
1965	447599	437200	3.01016	3.10812	5.49385	38	474	0.871475	2.6071
1966	951639	426800	2.76837	2.83326	4.66908	38	456	0.976860	5.0488
1967	1778360	368400	2.42073	2.21741	3.92769	37	438	0.968342	5.4551
1968	1513126	386600	2.48506	2.09825	4.14114	37	418	0.968869	4.5335
1969	1119659	419200	2.72111	2.20600	4.52829	37	399	0.958552	4.1962
1970	540827	469800	3.20389	3.07858	5.37605	37	379	0.970096	7.0001
1971	582359	447200	3.10463	3.47911	5.25216	37	360	0.961036	5.5250
1972	514566	488400	3.31645	3.80738	5.46505	37	340	0.920591	5.8255
1973	1335775	506000	2.83446	3.56707	4.54012	37	332	0.953372	17.0091
1974	2376611	462200	2.48766	3.36423	3.86325	37	324	0.975261	22.0012
1975	2262841	425000	2.18008	3.28927	3.82765	37	316	0.950678	15.4020
1976	2973733	512000	2.11611	3.01027	3.73671	37	308	0.907194	6.8866
1977	1820790	562000	2.10637	2.95893	4.33289	37	300	0.968818	10.6646
1978	2556134	630200	2.34039	3.00971	4.10489	37	292	0.976653	14.6620

YR	CNSQ	LN	PE	AG	UY	NP	SV	ER	TT	CVSQ	H	S
1961	1521	0.882280	1	84	3.24	9	99.05	1	1	20.509	14424.8	16871.6
1962	1600	0.872461	1	85	3.46	8	99.05	1	2	17.054	22390.1	33115.1
1963	1600	0.952003	1	86	3.39	8	99.05	1	3	6.610	17783.7	30513.5
1964	1521	0.898026	1	87	3.27	9	99.05	1	4	105.590	14330.9	26526.7
1965	1444	0.870050	1	88	3.24	8	99.05	1	5	6.797	16782.9	22452.7
1966	1444	0.761808	1	89	3.90	7	99.05	1	6	25.490	20334.7	28581.3
1967	1369	0.709851	1	90	4.19	7	99.05	1	7	29.758	23971.0	42268.6
1968	1369	0.856164	1	91	4.50	9	99.05	1	8	20.556	25395.3	46581.5
1969	1369	0.962155	1	92	4.92	11	99.05	1	9	17.608	22514.8	44556.4
1970	1369	0.875146	1	93	5.81	11	99.05	1	10	49.001	16105.5	22896.9
1971	1369	0.750000	1	94	5.45	11	99.05	1	11	35.105	16259.8	16309.4
1972	1369	0.791557	1	95	5.83	12	99.05	1	12	33.936	14127.7	13581.1
1973	1369	0.540151	1	96	6.37	10	99.05	1	13	289.309	24615.5	17358.9
1974	1369	0.253764	1	97	9.10	12	99.05	1	14	484.053	31838.5	19077.5
1975	1369	0.336747	1	98	8.74	12	99.05	1	15	237.222	39605.2	18830.0
1976	1369	0.382771	1	99	7.78	12	99.05	1	16	47.425	50458.0	28648.6
1977	1369	0.830258	1	100	7.39	13	99.05	1	17	113.734	57334.7	31346.3
1978	1369	0.855242	1	101	8.33	14	99.05	1	18	214.975	48793.7	36170.9

TABLE C.2 COMMODITY TIME SERIES DATA

T=WHEAT(KANSAS CITY)

YR	HHH	SSS	SH	LH	SS	LS	NR	TR
1961	4239.6	936.84	1786.0	1402.6	365.0	339.6	1283.2	3893.2
1962	7414.8	1307.62	3574.2	2141.6	412.4	595.6	1998.6	6723.8
1963	7032.3	2550.09	3156.8	1934.4	525.8	860.6	2645.0	6937.4
1964	6015.1	2352.88	2572.6	1943.2	972.8	793.6	2085.8	6282.2
1965	5554.8	2085.62	2755.0	1345.0	557.0	942.4	2001.0	5639.4
1966	9661.7	1865.47	4581.0	2515.6	526.4	843.8	3060.4	8466.8
1967	12398.3	2535.68	6180.8	2619.4	552.0	1247.8	4334.0	10600.0
1968	16249.3	3581.54	8044.8	4322.0	1146.2	1579.6	4738.2	15092.6
1969	11909.8	2859.79	6193.6	3078.4	653.6	1532.8	3271.2	11496.4
1970	9875.1	1373.25	4887.4	2963.8	436.6	655.2	2305.4	8943.0
1971	13234.2	1370.17	6382.0	4698.6	335.6	811.6	2376.6	12227.8
1972	8460.0	1012.04	3743.8	3649.2	413.2	471.2	1194.6	8277.4
1973	26391.3	1364.29	12483.4	12323.8	590.2	692.2	1666.0	26089.6
1974	19982.3	838.08	9021.2	9514.4	423.2	354.2	1507.4	19313.0
1975	22950.4	1022.00	9570.8	10518.6	448.8	445.8	2988.4	20984.0
1976	37514.3	2048.48	17634.0	17417.6	689.6	1224.4	2597.2	36965.6
1977	35427.0	1517.21	16205.0	15864.0	705.6	667.8	3501.8	33442.4
1978	35187.3	1767.08	14913.2	14302.6	712.8	771.0	6274.8	30695.6

YR	V	TS	HH	ST	VV	CN	FN	CC	CV
1961	62460	222200	3.93985	5.46460	6.78939	39	587	0.901743	2.4727
1962	91746	215000	3.33207	5.09633	6.37137	40	549	0.968346	2.8193
1963	106958	164600	3.10934	4.15177	5.94594	40	510	0.885439	3.6822
1964	111426	182800	3.38066	4.33980	6.01405	39	492	0.881186	7.5649
1965	86767	204200	3.57686	4.57377	6.37563	38	474	0.942813	4.2224
1966	152203	203400	2.99834	4.68245	5.80842	38	456	0.975777	5.7244
1967	221608	211400	2.77575	4.41122	5.47010	37	438	0.976498	4.8186
1968	235143	238800	2.61711	4.18472	5.53295	37	418	0.950883	3.0380
1969	171373	243400	2.96718	4.43214	5.86950	37	399	0.956881	1.8653
1970	141443	226200	3.08676	5.09815	5.98848	37	379	0.967468	4.4223
1971	201309	218200	2.74004	5.06418	5.59833	37	360	0.852544	4.4051
1972	129871	228800	3.25983	5.41645	6.08549	37	340	0.836275	1.9534
1973	402163	237000	2.07697	5.15165	4.98585	37	332	0.926488	15.3139
1974	426686	255600	2.46736	5.71697	5.00233	37	324	0.985982	18.3391
1975	608901	275000	2.39629	5.59128	4.71768	37	316	0.992680	13.7269
1976	687811	328000	2.04683	5.06965	4.77254	37	308	0.933041	6.3241
1977	617122	312000	2.05500	5.32125	4.83145	37	300	0.989425	13.3643
1978	755945	307400	2.04590	5.14174	4.61175	37	292	0.981980	11.1043

YR	CNSQ	LN	PE	AG	UY	NP	SV	ER	TT	CVSQ	H	S
1961	1521	1.04282	1	84	3.24	2	99.05	4	1	6.114	3979.0	1197.36
1962	1600	1.00080	1	85	3.46	3	99.05	4	2	7.949	7025.5	1696.91
1963	1600	1.01584	1	86	3.39	1	99.05	4	3	13.559	6496.5	3085.89
1964	1521	0.97093	1	87	3.27	4	99.05	4	4	57.227	5641.4	2726.60
1965	1444	0.96378	1	88	3.24	3	99.05	4	5	17.829	5173.8	2466.62
1966	1444	0.87640	1	89	3.90	3	99.05	4	6	32.769	8980.7	2546.50
1967	1369	0.78571	1	90	4.19	3	99.05	3	7	23.219	11354.1	3579.89
1968	1369	0.91325	1	91	4.50	3	99.05	5	8	9.229	15321.6	4509.18
1969	1369	1.03971	1	92	4.92	2	99.05	5	9	3.554	11325.6	3444.02
1970	1369	1.02293	1	93	5.81	3	99.05	4	10	19.557	9460.3	1788.07
1971	1369	0.94281	1	94	5.45	2	99.05	5	11	19.405	12883.8	1720.63
1972	1369	0.95157	1	95	5.83	2	99.05	5	12	3.816	8325.4	1146.60
1973	1369	0.64470	1	96	6.37	3	99.05	5	13	234.514	26296.2	1459.37
1974	1369	0.26825	1	97	9.10	2	99.05	5	14	336.323	19877.6	942.82
1975	1369	0.33683	1	98	8.74	1	99.05	5	15	188.427	22593.7	1378.65
1976	1369	0.36508	1	99	7.78	2	99.05	5	16	39.994	37352.7	2210.15
1977	1369	0.81497	1	100	7.39	1	99.05	5	17	178.604	35108.7	1835.50
1978	1369	0.78495	1	101	8.33	1	99.05	5	18	123.305	34173.9	2600.49

TABLE C. 3 COMMODITY TIME SERIES DATA

T=WHEAT(MINNEAPOLIS)

YR	HHH	SSS	SH	LH	SS	LS	NR	TR	V
1961	2565.2	13.646	1118.0	837.0	4.4	6.0	613.4	1965.4	41280
1962	2708.9	111.899	1185.8	857.4	22.2	62.2	693.2	2127.6	47249
1963	2015.4	194.184	711.0	762.8	44.2	97.8	593.8	1615.8	42016
1964	1969.4	97.773	767.0	840.4	40.8	39.0	380.0	1687.2	41504
1965	1556.8	110.811	632.8	628.8	85.2	4.6	316.2	1351.4	27017
1966	2910.8	110.033	1316.2	1075.2	26.0	64.4	539.0	2481.3	47336
1967	3685.4	46.978	1528.0	1296.2	10.6	25.2	872.2	2860.2	67517
1968	3625.1	98.470	1422.2	1037.0	32.0	34.8	1197.6	2526.0	73067
1969	3427.9	568.508	1460.0	1103.8	74.8	350.4	1007.4	2989.0	65510
1970	2601.4	47.767	891.2	1167.4	33.6	4.2	552.8	2096.4	41882
1971	2875.9	42.527	1210.0	1238.0	0.0	36.2	434.2	2484.2	53765
1972	2810.9	59.507	1160.0	1116.8	3.2	45.0	545.4	2325.0	55393
1973	9885.6	169.564	3323.6	4442.0	33.2	100.0	2156.4	7898.8	167472
1974	8760.0	213.629	3422.0	4082.0	84.4	98.6	1286.6	7687.0	174574
1975	8900.6	250.239	3920.8	4153.2	92.0	135.0	849.8	8301.0	157134
1976	10980.9	341.454	5046.2	4923.2	50.4	259.6	1043.0	10279.4	228084
1977	10038.1	405.131	4781.8	3697.0	27.6	314.6	1622.2	8821.0	191098
1978	11369.5	897.315	4659.0	3802.4	92.2	575.6	3137.6	9129.2	284313

YR	TS	HH	ST	VV	CN	FN	CC	CV	CNSC
1961	41800	2.72755	8.02689	5.53002	39	587	0.78705	2.4727	1521
1962	27200	2.20177	5.48926	4.96227	40	549	0.77097	2.5084	1600
1963	39800	2.93108	5.31792	5.46305	40	510	-0.08303	1.5993	1600
1964	36200	2.85538	5.91146	5.38013	39	492	0.20672	2.2312	1521
1965	38800	3.17484	5.85549	5.88063	38	474	-0.12628	2.2142	1444
1966	45800	2.69020	6.02885	5.48433	38	456	0.66652	2.3800	1444
1967	37000	2.20161	6.66772	4.91267	37	438	0.95670	3.3107	1369
1968	49400	2.53585	6.21595	5.12410	37	418	0.71219	2.5511	1369
1969	47800	2.56067	4.41980	5.20079	37	399	0.31290	2.7652	1369
1970	40600	2.68149	6.74400	5.48624	37	379	0.67378	2.8013	1369
1971	41400	2.59493	6.87986	5.25491	37	360	0.84735	2.9398	1369
1972	76400	3.26499	7.15687	5.84009	37	340	0.40236	1.7530	1369
1973	57400	1.56995	5.82161	4.43895	37	332	0.69491	12.2712	1369
1974	70800	1.95759	5.80035	4.60906	37	324	0.92940	15.1670	1369
1975	65000	1.84101	5.55587	4.39576	37	316	0.95128	9.8202	1369
1976	71800	1.71174	5.34366	4.35284	37	308	0.85211	4.3107	1369
1977	89400	2.06763	5.39212	4.75321	37	300	0.98467	13.7028	1369
1978	83800	1.85169	4.52602	4.28615	37	292	0.99240	8.5395	1369

YR	LN	PE	AG	UY	NP	SV	ER	TT	CVSC	H	S
1961	0.987749	1	76	3.24	4	97.08	5	1	6.114	2420.0	158.78
1962	0.890722	1	77	3.46	4	97.08	5	2	6.292	2545.3	275.45
1963	0.947899	1	78	3.39	3	97.08	5	3	2.558	1869.9	339.74
1964	0.921436	1	79	3.27	3	97.08	5	4	4.978	1902.9	164.32
1965	0.906315	1	80	3.24	2	97.08	5	5	4.903	1500.8	166.78
1966	0.846807	1	81	3.90	1	97.03	5	6	5.664	2818.1	202.70
1967	0.781302	1	82	4.19	1	97.08	5	7	10.961	3484.2	248.23
1968	0.831099	1	83	4.50	3	97.08	6	8	6.508	3250.1	473.46
1969	0.878673	1	84	4.92	1	97.08	6	9	7.646	3210.1	786.33
1970	0.855197	1	85	5.81	3	97.08	6	10	7.847	2488.2	161.04
1971	0.845745	1	86	5.45	3	97.08	6	11	8.642	2812.2	106.19
1972	0.941860	1	87	5.83	2	97.08	6	12	3.073	2709.4	160.95
1973	0.714651	1	88	6.37	2	97.08	6	13	150.582	9431.0	624.22
1974	0.277151	1	89	9.10	3	97.08	6	14	230.037	8579.9	353.71
1975	0.280950	1	90	8.74	2	97.08	6	15	96.437	8823.8	327.00
1976	0.291961	1	91	7.78	2	97.08	6	16	18.582	10887.8	434.64
1977	0.685111	1	92	7.39	2	97.08	6	17	187.766	9795.9	647.34
1978	0.772650	1	93	8.33	1	97.08	6	18	72.924	10625.7	1641.14

TABLE C.4 COMMODITY TIME SERIES DATA

T=CORN

YR	HHH	SSS	SH	LH	SS	LS	NR	TR
1961	21646	11171.1	9207.4	4556.2	2989.4	4113.8	11950.0	20667
1962	37417	39029.0	18258.4	4662.8	10295.2	13613.8	29615.4	46830
1963	27491	21729.5	13131.0	5585.0	5702.0	9091.8	15710.2	33510
1964	31199	20095.6	12904.8	8500.0	5723.0	8064.0	16103.0	35192
1965	43911	19135.9	19517.8	12653.0	5203.4	8816.2	16856.8	46190
1966	45767	20221.5	17959.6	13451.8	6590.0	7288.8	20697.8	45250
1967	76377	53512.9	36341.6	12377.4	14292.6	20097.2	47180.8	83109
1968	58513	35122.3	22798.4	15970.2	11493.0	11777.8	31595.8	62039
1969	56973	40423.9	23107.2	15490.6	12974.8	14411.4	31412.8	65584
1970	49383	32618.7	19789.0	14862.4	11113.2	11774.8	24462.6	57539
1971	84001	48110.1	37419.6	18195.4	12445.4	19407.2	44643.2	87468
1972	66461	26755.7	25545.6	19182.6	8519.2	9487.4	30481.6	62735
1973	119336	30504.5	49143.6	42029.0	9284.6	14020.8	35362.4	114478
1974	116240	32191.0	45929.2	44564.2	11141.4	13919.4	32877.0	115554
1975	121031	34604.1	44962.0	46752.2	11811.8	14410.2	37699.4	117936
1976	143165	32331.2	51907.2	61324.2	13105.8	12465.4	36694.0	138803
1977	156795	41096.1	54943.2	62679.6	17192.4	13638.2	49439.2	148453
1978	223238	41024.8	83697.6	74901.4	12556.2	16589.8	76517.4	187745

YR	V	TS	HH	ST	VV	CN	FN	CC	CV
1961	423380	1139000	3.94391	4.61472	6.50961	22	2096	0.944899	6.0037
1962	976640	1123000	3.36776	3.32408	5.65762	22	2123	0.754615	2.3459
1963	701407	1052000	3.61813	3.85891	5.52415	22	2150	0.972932	5.7749
1964	750598	1077000	3.51215	3.96260	5.87573	22	2071	0.935435	5.1721
1965	738895	1004400	3.08527	3.94134	5.82550	23	1992	0.942120	4.5170
1966	1073395	1050200	3.08863	3.93055	5.49552	23	1914	0.831776	4.3914
1967	2597589	1002200	2.49501	2.86729	4.55865	23	1835	0.674538	3.1808
1968	1504282	1137400	2.91444	3.44630	5.23659	23	1784	0.722528	5.0974
1969	1706577	1124000	2.93006	3.28860	5.09777	24	1733	0.981176	7.1512
1970	1290576	1161200	3.11414	3.54383	5.41137	24	1681	0.909701	4.5698
1971	2734435	1032200	2.42374	3.01823	4.53658	23	1630	0.757526	4.8242
1972	1549987	1261800	2.88957	3.83212	5.31083	23	1579	0.929141	8.7189
1973	3481011	1340000	2.32521	3.75952	4.55636	23	1562	0.955395	21.6141
1974	4679042	1276000	2.30031	3.65425	4.20732	23	1545	0.799059	9.1813
1975	4835049	1037400	2.02437	3.36657	3.96347	23	1527	0.944595	10.8413
1976	4609262	1238400	2.03472	3.61909	4.19221	23	1510	0.943940	6.3933
1977	5021827	1333600	2.01562	3.44837	4.18037	23	1493	0.959565	8.2249
1978	6127099	1462400	1.71395	3.54520	4.07192	23	1476	0.979455	12.6953

YR	CNSQ	LN	PE	AG	UY	NP	SV	ER	TT	CVSQ	H	S
1961	484	0.96073	1	84	3.24	9	95	1	1	36.045	18776	14041.3
1962	484	1.08352	1	85	3.46	8	95	1	2	5.503	31801	44644.6
1963	484	1.03523	1	86	3.39	8	95	1	3	33.349	24690	24530.2
1964	484	1.00671	1	87	3.27	9	95	1	4	26.751	28124	23170.4
1965	529	0.98425	1	88	3.24	8	95	1	5	20.404	40772	22275.0
1966	529	0.99075	1	89	3.90	7	95	1	6	19.284	41264	24724.1
1967	529	0.93694	1	90	4.19	7	95	1	7	10.117	66361	63928.4
1968	529	1.17391	1	91	4.50	9	95	1	8	25.984	51850	41784.7
1969	576	1.17052	1	92	4.92	11	95	1	9	51.713	51047	46350.3
1970	576	1.09682	1	93	5.81	11	95	1	10	24.898	44989	37013.5
1971	529	0.90000	1	94	5.45	11	95	1	11	23.273	74409	57702.2
1972	529	1.09533	1	95	5.83	12	95	1	12	76.019	59354	33862.2
1973	529	0.89714	1	96	6.37	10	95	1	13	467.168	112689	37151.0
1974	529	0.59799	1	97	9.10	12	95	1	14	84.257	110537	37893.8
1975	529	0.33837	1	98	8.74	12	95	1	15	117.533	113930	41705.6
1976	529	0.39450	1	99	7.78	12	95	1	16	40.874	136907	38590.0
1977	529	0.58766	1	100	7.39	13	95	1	17	67.649	147008	50884.3
1978	529	0.91778	1	101	8.33	14	95	1	18	161.169	204521	59740.9

TABLE C. 5 COMMODITY TIME SERIES DATA

T=OATS

YR	HHH	SSS	SH	LH	SS	LS	NR	TR
1961	9015.31	5418.7	4316.4	351.4	1084.6	1721.0	6960.6	7473.4
1962	8931.60	13869.2	4320.8	135.6	3368.2	3551.8	11424.4	11376.4
1963	5746.38	7905.6	2750.2	452.4	2113.8	2292.2	6043.4	7608.6
1964	7003.42	4513.4	3189.8	504.8	1254.8	1126.2	5441.2	6075.6
1965	5723.02	3403.8	2316.2	427.8	804.6	827.4	4750.8	4376.0
1966	5049.79	1464.2	1625.2	517.2	263.8	357.4	3750.4	2763.6
1967	7736.24	2220.6	3547.0	264.4	311.8	782.2	5051.4	4905.4
1968	2941.30	2484.3	784.0	375.8	485.6	494.0	3286.2	2139.4
1969	4703.77	3809.4	1343.6	521.4	691.2	819.2	5137.8	3375.4
1970	5835.27	4137.5	2487.0	452.4	863.2	1221.0	4949.2	5023.6
1971	2806.37	3089.2	1292.0	99.0	545.6	985.6	2973.4	2922.2
1972	1300.68	2895.1	509.4	178.2	545.6	985.6	1976.4	2218.8
1973	2593.21	806.8	689.8	42.4	100.4	127.4	2440.0	960.0
1974	5588.74	1626.5	2158.2	709.4	310.8	468.0	3968.8	3646.4
1975	4404.85	1456.8	1089.2	872.0	266.6	382.0	3251.8	2609.8
1976	4300.51	1407.5	1011.2	917.4	296.2	335.0	3148.2	2559.8
1977	5326.44	600.6	1182.4	1026.0	121.6	127.4	3469.6	2457.4
1978	7090.26	2511.5	2358.2	1008.6	550.4	642.2	5042.4	4559.4

YR	V	TS	HH	ST	VV	CN	FN	CC	CV
1961	163540	284200	3.41852	3.94057	6.07178	22	2096	0.746556	3.8348
1962	315418	267000	3.36363	2.90424	5.35007	22	2123	0.456892	3.3990
1963	175676	258400	3.78345	3.45586	5.90461	22	2150	0.912753	6.1321
1964	122017	248600	3.54087	3.99048	6.23118	22	2071	0.911921	4.0753
1965	96410	233600	3.68431	4.21405	6.40481	23	1992	0.959216	5.7365
1966	79510	242000	3.84850	5.10155	6.63320	23	1914	0.760089	2.6809
1967	113515	224800	3.33428	4.60752	6.20272	23	1835	0.311931	2.3911
1968	81816	213600	4.27139	4.44241	6.47556	23	1784	0.754544	4.0361
1969	136864	245400	3.93517	4.14977	6.10313	24	1733	0.927732	4.8150
1970	104101	269400	3.81038	4.16062	6.47075	24	1681	0.465121	4.2039
1971	76482	283600	4.60573	4.50869	6.83089	23	1630	0.708270	5.1525
1972	36282	280400	5.36914	4.56281	7.56584	23	1579	0.466189	4.1301
1973	182963	247200	4.54676	5.72162	5.81941	23	1562	0.826753	10.4906
1974	199486	215400	3.55442	4.87851	5.59450	23	1545	0.880116	13.8328
1975	154067	173800	3.64953	4.77328	5.63843	23	1527	0.901566	6.6505
1976	126885	173000	3.66939	4.80332	5.82653	23	1510	0.880195	4.9561
1977	109970	150600	3.30594	5.52052	5.83296	23	1493	0.925799	7.2234
1978	215774	183600	3.21465	4.27809	5.35526	23	1476	0.976677	10.0254

YR	CNSQ	LN	PE	AG	UY	NP	SV	ER	TT	CVSQ	H	S
1961	484	0.738007	1	84	3.24	9	95	1	1	14.706	6918.78	7515.2
1962	484	0.700535	1	85	3.46	8	95	1	2	11.553	6689.29	16111.5
1963	484	0.856157	1	86	3.39	8	95	1	3	37.603	4620.31	9031.7
1964	484	0.933014	1	87	3.27	9	95	1	4	16.608	5440.14	6076.7
1965	529	0.886364	1	88	3.24	8	95	1	5	32.908	4172.34	4954.5
1966	529	0.893300	1	89	3.90	7	95	1	6	7.187	3375.88	3138.1
1967	529	0.820046	1	90	4.19	7	95	1	7	5.717	5745.04	4211.8
1968	529	0.878049	1	91	4.50	9	95	1	8	16.290	1862.27	3563.3
1969	576	0.958175	1	92	4.92	11	95	1	9	23.184	2990.55	5522.7
1970	576	0.980545	1	93	5.81	11	95	1	10	17.673	4398.14	5574.7
1971	529	0.757855	1	94	5.45	11	95	1	11	26.548	2092.54	3803.1
1972	529	0.812030	1	95	5.83	12	95	1	12	17.474	1011.54	3183.7
1973	529	0.658537	1	96	6.37	10	95	1	13	110.054	1257.66	2142.3
1974	529	0.401736	1	97	9.10	12	95	1	14	191.345	4362.10	3253.1
1975	529	0.308131	1	98	8.74	12	95	1	15	44.230	3049.20	2812.4
1976	529	0.320158	1	99	7.78	12	95	1	16	24.563	2992.30	2715.7
1977	529	0.607670	1	100	7.39	13	95	1	17	52.178	3501.17	2425.8
1978	529	0.809430	1	101	8.33	14	95	1	18	100.509	5134.88	4466.9

TABLE C.6 COMMODITY TIME SERIES DATA

T=SOYBEANS

YR	HHH	SSS	SH	LH	SS	LS	NR	TR
1961	31851	46145.4	16622.4	2538.4	11481.6	16278.0	31076.4	46920
1962	19423	44046.0	7542.6	4277.8	13027.8	13777.8	24842.8	38626
1963	27191	39581.3	11617.4	5076.4	11339.8	13252.0	25286.8	41486
1964	39419	63112.5	16643.8	7710.6	19202.2	19790.4	39185.C	62347
1965	47965	70642.8	20466.2	10555.2	21317.8	24370.6	41897.8	76710
1966	37240	58559.9	12659.8	10760.6	17924.8	19155.2	35699.6	60500
1967	33974	52156.0	9776.8	13644.4	19075.2	16880.0	26754.0	55376
1968	29881	39581.8	12604.4	8722.8	13455.6	14795.0	19885.4	49578
1969	31121	35648.6	11106.8	12417.C	13752.2	13194.0	16299.6	50470
1970	44056	31294.6	15857.6	18458.4	12619.8	11756.0	16659.0	58692
1971	59375	54018.6	23194.6	19515.C	18132.8	20723.8	31827.4	81566
1972	57940	65190.4	20998.6	17957.0	20984.0	22846.4	40344.4	82786
1973	77733	50926.6	27513.8	31849.4	19552.4	19339.2	30405.0	98255
1974	65099	37291.1	23031.6	27359.6	14938.4	13927.6	23132.8	79257
1975	57982	39640.6	20533.2	25010.8	16516.0	14621.2	20941.2	76681
1976	71460	77741.6	29877.0	25782.2	29573.6	30578.6	32990.2	116211
1977	95488	98873.9	40901.4	31139.2	34551.2	40044.0	47726.C	146636
1978	114323	89665.6	39251.6	33813.2	27099.6	30206.4	73617.8	130371

YR	V	TS	HH	ST	VV	CN	FN	CC	CV
1961	2486800	121400	1.03370	0.48908	2.41631	46	67	0.994442	16.5391
1962	960100	141200	1.83574	0.79106	3.57703	48	68	0.855381	3.1310
1963	1657135	149400	1.50284	1.02047	3.06986	50	68	0.969286	3.2374
1964	2707904	149000	1.02240	0.30812	2.54600	52	66	0.973573	3.3683
1965	3859364	153600	0.78952	0.16069	2.19163	55	64	0.981396	6.2201
1966	3205754	175000	1.30813	0.67708	2.53745	57	62	0.980463	8.5584
1967	1870487	192800	1.54220	0.99199	3.20558	55	60	0.995641	9.3655
1968	950193	213200	1.81399	1.47849	4.00904	55	59	0.939741	2.5724
1969	932815	254600	1.97144	1.81514	4.20818	56	58	0.977116	3.0371
1970	1271613	291800	1.72693	2.11918	4.03190	56	56	0.912992	4.3234
1971	2652912	271400	1.27283	1.39233	3.20176	55	55	0.963716	3.9135
1972	3890354	255000	1.22410	1.06871	2.73350	54	54	0.961053	5.4903
1973	3649635	266600	0.89829	1.45261	2.85642	54	56	0.997024	45.2893
1974	2731297	321400	1.37045	2.03060	3.34703	54	58	0.936903	18.4221
1975	3913804	277400	1.33085	1.79141	2.81657	54	61	0.971420	16.5650
1976	5474179	347000	1.34960	1.24228	2.65781	54	63	0.974397	11.0390
1977	7996139	306400	0.79244	0.74141	2.14939	54	65	0.990695	15.8934
1978	8477277	373000	0.81655	1.15054	2.30258	54	67	0.975904	10.9305

YR	CNSQ	LN	PE	AG	UY	NP	SV	ER	TT	CVSQ	H	S
1961	2116	0.734856	1	25	3.24	9	93.53	1	1	273.54	26795.1	51202
1962	2304	0.916639	1	26	3.46	8	93.53	1	2	9.80	16447.1	47022
1963	2500	0.873504	1	27	3.39	8	93.53	1	3	10.48	23291.5	43481
1964	2704	0.839291	1	28	3.27	9	93.53	1	4	11.35	33662.0	68870
1965	3025	0.791325	1	29	3.24	8	93.53	1	5	38.69	41979.6	76628
1966	3249	0.792719	1	30	3.90	7	93.53	1	6	73.93	32111.7	64088
1967	3025	0.813229	1	31	4.19	7	93.53	1	7	87.72	30696.3	55434
1968	3025	0.923930	1	32	4.50	9	93.53	1	8	6.62	27432.6	42031
1969	3136	0.948467	1	33	4.92	11	93.53	1	9	9.22	29266.4	37503
1970	3136	0.875486	1	34	5.81	11	93.53	1	10	18.69	41902.8	33448
1971	3025	0.757363	1	35	5.45	11	93.53	1	11	15.32	54697.4	58696
1972	2916	0.690850	1	36	5.83	12	93.53	1	12	30.14	51719.6	71411
1973	2916	0.418799	1	37	6.37	10	93.53	1	13	2051.12	73392.0	55268
1974	2916	0.354983	1	38	9.10	12	93.53	1	14	339.37	61776.0	40614
1975	2916	0.340552	1	39	8.74	12	93.53	1	15	287.81	55313.7	42309
1976	2916	0.000000	1	40	7.78	12	93.53	1	16	121.86	67966.1	81236
1977	2916	0.336965	1	41	7.39	13	93.53	1	17	252.60	89730.3	104631
1978	2916	0.579790	1	42	8.33	14	93.53	1	18	119.48	99433.3	104555

TABLE C. 7 COMMODITY TIME SERIES DATA

T=SOYBEAN OIL

YR	HHH	SSS	SH	LH	SS	LS	NR	TR	V
1961	10277.6	9932.4	4578	2926	3342	3910	5454	14756	389725
1962	10930.7	8509.3	5043	2947	2759	3461	5230	14210	271869
1963	14316.5	15209.5	8596	3106	4093	7739	5392	24134	393195
1964	19751.5	16938.5	10792	6368	6477	8239	4814	31876	428856
1965	19562.5	15087.5	11063	3852	3967	7567	8161	26489	566332
1966	17487.1	16872.9	9934	3163	4740	7897	8626	25734	587305
1967	15109.8	15696.2	8414	3499	5007	7526	6560	24446	429746
1968	12562.8	9003.2	6167	4354	3362	4178	3505	18061	267328
1969	20767.5	11254.5	9936	6616	4202	4768	6500	25522	426416
1970	34844.4	18913.6	17279	9064	5384	8915	13116	40642	1672031
1971	38997.4	22318.6	17657	12365	7493	9975	13326	47990	1470048
1972	36574.1	25549.9	16247	13741	9990	10959	11187	50937	1365595
1973	38860.2	37477.8	17421	14989	16992	14265	12671	63667	1636845
1974	33535.9	27074.1	14276	12426	11036	10521	12351	48259	1542941
1975	29183.0	26435.0	10314	13676	12527	9204	9897	45721	1436263
1976	29642.7	39224.3	12646	12082	16874	15847	11418	57449	1487547
1977	46348.7	56938.3	22345	16788	23309	24765	16080	87207	2373177
1978	58514.1	40143.9	26880	20625	15320	17271	18562	80096	2775559

YR	TS	HH	ST	VV	CN	FN	CC	CV	CNSC
1961	55483	1.48126	1.52303	3.54359	43	67	0.993913	14.5091	1849
1962	59000	1.48107	1.78063	3.97507	45	68	0.982890	7.0564	2025
1963	60400	1.16905	1.08896	3.62175	46	68	0.965878	5.2372	2116
1964	67633	0.88550	1.09624	3.64875	48	66	0.898967	5.2383	2304
1965	67817	0.90287	1.25130	3.36511	50	64	0.974562	12.4754	2500
1966	78117	1.24332	1.28915	3.47359	53	62	0.895108	4.8865	2809
1967	80617	1.46681	1.40400	3.82642	55	60	0.922625	8.3095	3025
1968	84933	1.75106	2.13223	4.36218	54	59	0.921936	5.4171	2916
1969	95933	1.28631	2.01810	4.01176	53	58	0.901881	7.3688	2809
1970	105467	0.70645	1.52088	2.69255	53	56	0.985434	12.2215	2809
1971	104217	0.51426	1.30006	2.81681	52	55	0.959249	7.3381	2704
1972	107333	0.65994	1.16344	2.92582	51	54	0.984549	10.6372	2601
1973	111417	0.62439	0.67949	2.77365	51	56	0.988401	27.2765	2601
1974	120933	0.95785	1.24322	2.92287	51	58	0.893004	17.1739	2601
1975	108633	1.00155	1.13445	2.88530	51	61	0.985045	21.4811	2601
1976	131767	1.23697	0.85837	3.05140	51	63	0.989043	23.5674	2601
1977	124233	0.51904	0.16712	2.49215	51	65	0.985095	16.5194	2601
1978	136550	0.28790	0.87610	2.42470	51	67	0.976805	14.4139	2601

YR	LN	PE	AG	UY	NP	SV	ER	TT	CVSQ	H	S
1961	0	1	11	3.24	9	92.37	1	1	210.515	9529.1	10680.9
1962	0	1	12	3.46	8	92.37	1	2	49.793	10139.6	9200.4
1963	0	1	13	3.39	8	92.37	1	3	27.429	13839.0	15687.0
1964	0	1	14	3.27	9	92.37	1	4	27.440	19411.5	17278.5
1965	0	1	15	3.24	8	92.37	1	5	155.636	18477.3	16172.7
1966	0	1	16	3.90	7	92.37	1	6	23.878	16385.0	17975.0
1967	0	1	17	4.19	7	92.37	1	7	69.047	14433.5	16572.5
1968	0	1	18	4.50	9	92.37	1	8	29.345	12230.9	9335.1
1969	0	1	19	4.92	11	92.37	1	9	54.300	19911.8	12110.2
1970	0	1	20	5.81	11	92.37	1	10	149.364	32770.2	20987.8
1971	0	1	21	5.45	11	92.37	1	11	53.848	37155.4	24160.6
1972	0	1	22	5.83	12	92.37	1	12	113.150	35388.1	26735.9
1973	0	1	23	6.37	10	92.37	1	13	744.007	37739.6	38548.4
1974	0	1	24	9.10	12	92.37	1	14	294.942	32143.3	28466.7
1975	0	1	25	8.74	12	92.37	1	15	461.437	28258.9	27359.1
1976	0	1	26	7.78	12	92.37	1	16	555.423	28827.8	40039.2
1977	0	1	27	7.39	13	92.37	1	17	272.892	45225.3	58061.7
1978	0	1	28	8.33	14	92.37	1	18	207.760	56442.8	42215.2

TABLE C. 8 COMMODITY TIME SERIES DATA

T=SOYBEAN MEAL

YR	HHH	SSS	SH	LH	SS	LS	NR	TR	V
1961	8030.3	6627.7	4173	1312	1509	2918	4646	10012	251701
1962	8369.4	8968.6	3191	2480	2937	3140	5590	11748	271724
1963	8956.8	8513.2	3828	3276	2752	3322	5292	13178	331563
1964	14714.3	6966.7	6657	4469	2325	2942	5287	16393	270255
1965	16200.3	8557.7	7182	6062	3210	3786	4518	20240	301876
1966	16590.4	7383.6	6540	5953	2665	2895	5921	18053	377329
1967	16791.2	9216.8	6434	5639	3160	3467	7308	18700	423178
1968	13736.1	9085.9	4755	5374	3454	3246	5993	16829	332846
1969	20734.8	9249.2	8435	8143	3806	3589	6011	23973	405644
1970	28707.2	13608.8	13163	8963	4654	5835	9701	32615	717604
1971	32800.6	17801.5	14567	10888	6348	7467	11332	39270	634164
1972	18523.8	13564.2	7503	6387	4948	5223	8027	24061	485789
1973	27217.8	17292.2	11115	11807	7848	6715	7025	37485	723404
1974	26776.1	17581.9	10035	10520	7471	6026	10306	34052	705315
1975	25398.0	17266.0	8814	10556	8035	5133	10126	32538	824179
1976	15220.1	11453.9	7661	4766	4211	3141	4895	21779	1071450
1977	50875.7	32708.3	22299	19673	13405	13579	14628	68956	2193064
1978	59554.5	29677.5	25403	22377	11359	12435	17698	71574	2354960

YR	TS	HH	ST	VV	CN	FN	CC	CV	CNSC
1961	95350	2.38636	2.59425	4.54016	44	67	0.979177	15.0853	1936
1962	104200	2.43800	2.36258	4.55250	47	68	0.917755	5.6306	2205
1963	112210	2.32919	2.49985	4.42606	49	68	0.574916	3.3285	2401
1964	107680	1.84341	2.67129	4.59117	51	66	0.960959	4.9943	2601
1965	114080	1.79871	2.51210	4.53770	52	64	0.934484	3.9341	2704
1966	130070	1.92280	2.81038	4.44474	54	62	0.889203	7.5540	2916
1967	136150	1.96128	2.62263	4.37491	56	60	0.988514	9.1883	3136
1968	137980	2.20222	2.65226	4.63119	55	59	0.920045	3.3560	3025
1969	147260	1.80863	2.70279	4.49711	55	58	0.946823	6.7417	3025
1970	177530	1.64561	2.48867	4.10838	54	56	0.890937	7.0382	2916
1971	181720	1.51296	2.22008	4.25756	54	55	0.839281	3.3068	2916
1972	171700	2.11253	2.45602	4.47005	53	54	0.789718	8.5325	2809
1973	169010	1.65045	2.17176	4.05018	53	56	0.996376	49.1537	2809
1974	198570	1.85879	2.33156	4.23965	53	58	0.898857	35.2342	2809
1975	172090	1.75366	2.19355	3.93575	53	61	0.939183	11.3793	2809
1976	211120	2.55499	2.85931	3.87661	53	63	0.969464	13.2185	2809
1977	188430	0.99463	1.56044	3.01946	53	65	0.744777	15.2815	2809
1978	225990	1.02680	1.88932	3.13510	53	67	0.513495	8.5705	2809

YR	LN	PE	AG	UY	NP	SV	ER	TT	CVSQ	H	S
1961	0	1	10	3.24	9	93.53	1	1	227.57	7223.5	7434.5
1962	0	1	11	3.46	8	93.53	1	2	31.70	7499.4	9838.6
1963	0	1	12	3.39	8	93.53	1	3	11.08	9139.4	9330.6
1964	0	1	13	3.27	9	93.53	1	4	24.94	13839.2	7840.8
1965	0	1	14	3.24	8	93.53	1	5	15.48	15660.5	9097.1
1966	0	1	15	3.90	7	93.53	1	6	57.06	15578.5	8395.5
1967	0	1	16	4.19	7	93.53	1	7	84.42	15465.4	10542.6
1968	0	1	17	4.50	9	93.53	1	8	11.26	12788.5	10033.1
1969	0	1	18	4.92	11	93.53	1	9	45.45	19901.5	10082.5
1970	0	1	19	5.81	11	93.53	1	10	49.54	27198.4	15117.6
1971	0	1	20	5.45	11	93.53	1	11	10.93	31155.5	19446.5
1972	0	1	21	5.83	12	93.53	1	12	72.80	17364.7	14723.3
1973	0	1	22	6.37	10	93.53	1	13	2416.08	26539.6	17970.2
1974	0	1	23	9.10	12	93.53	1	14	1241.45	25330.7	19027.3
1975	0	1	24	8.74	12	93.53	1	15	129.49	23987.3	18696.7
1976	0	1	25	7.78	12	93.53	1	16	174.73	14707.5	11966.5
1977	0	1	26	7.39	13	93.53	1	17	233.52	49317.5	34266.5
1978	0	1	27	8.33	14	93.53	1	18	73.45	57252.3	32019.7

TABLE C. 9 COMMODITY TIME SERIES DATA

T=POTATOE

YR	HHH	SSS	SH	LH	SS	LS	NR	TR	V
1961	6537.6	6334.4	2289	962	1619	1531	6471	6401	188911
1962	9946.0	9492.0	4719	846	2079	3232	8562	10876	237688
1963	7479.5	7366.5	3334	502	1495	2283	7232	7614	152056
1964	7270.8	5283.2	3017	908	1154	1698	5777	6777	178680
1965	11405.7	14432.3	4671	1381	2397	5261	12128	13710	602521
1966	9318.5	17183.5	3664	1087	4027	4734	12990	13512	412970
1967	8347.4	21886.6	3244	441	4519	5143	16887	13347	702460
1968	9668.4	19827.6	3858	535	4239	4770	16094	13402	411473
1969	10262.2	19901.8	3666	439	3114	4847	18098	12066	478589
1970	5144.6	14221.4	1692	213	2050	3216	12195	7171	335253
1971	4641.1	13722.9	1183	622	2752	2585	11222	7142	205694
1972	2845.4	7858.6	1100	114	1617	1753	6160	4584	152634
1973	8999.8	16992.2	4102	409	2260	6257	12964	13028	385616
1974	9125.3	19658.7	3613	593	3236	5825	15517	13267	770781
1975	10318.3	19173.7	4324	486	4539	4399	15744	13748	795732
1976	12814.3	16281.7	6051	553	2476	5915	14101	14955	456670
1977	5277.5	9175.5	2215	413	1695	2874	7256	7197	519806
1978	9958.9	17285.1	4330	618	3515	5073	13708	13536	453215

YR	TS	HH	ST	VV	CN	FN	CC	CV
1961	68000	2.24086	2.27572	4.46852	39	1977	0.12154	11.4841
1962	74000	1.86256	1.91634	4.34164	40	1977	0.50716	29.2889
1963	78000	2.24373	2.26057	4.84609	41	1977	0.17162	11.3743
1964	76000	2.24630	2.59416	4.65715	41	1939	0.37722	38.1388
1965	76000	1.73402	1.45067	3.41885	41	1900	-0.20287	26.0005
1966	72000	1.90607	1.16004	3.75154	41	1862	0.27229	35.8200
1967	76000	2.09244	0.90521	3.25993	41	1824	0.47947	12.8236
1968	76000	1.92580	1.04135	3.81056	43	1830	0.01690	22.4229
1969	72000	1.79443	0.96232	3.60034	44	1837	-0.40736	24.3832
1970	70000	2.53420	1.36665	3.93573	46	1843	0.16890	21.2852
1971	72000	2.67507	1.44615	4.46024	47	1850	0.37750	21.5710
1972	76000	3.24688	2.15431	4.81609	49	1856	0.05567	8.5522
1973	66000	1.84565	1.05923	3.73263	49	1660	0.23992	34.3840
1974	58000	1.67821	0.66801	2.87988	49	1864	0.46804	30.2313
1975	72000	1.78806	1.01347	3.07365	49	1867	0.62608	26.3044
1976	54000	1.16753	0.84010	3.35207	49	1871	-0.01587	22.8577
1977	54000	2.22268	1.58622	3.21772	49	1874	0.39690	35.6663
1978	56000	1.53107	0.80638	3.35754	49	1877	0.75187	26.5351

YR	CNSQ	LN	PE	AG	UY	NP	SV	ER	TT	CVSQ	H	S
1961	1521	0	1	20	3.24	1	74.49	3	1	131.88	4885.34	7986.7
1962	1600	0	1	21	3.46	1	74.49	3	2	857.84	8016.26	11421.7
1963	1681	0	1	22	3.39	1	74.49	3	3	129.37	5704.65	9141.4
1964	1681	0	1	23	3.27	2	74.49	3	4	1454.57	5731.18	6822.8
1965	1681	0	1	24	3.24	1	74.49	3	5	676.03	8892.73	16945.3
1966	1681	0	1	25	3.90	2	74.49	3	6	1283.07	7079.71	19422.3
1967	1681	0	1	26	4.19	2	74.49	4	7	156.84	5743.23	24490.8
1968	1849	0	1	27	4.50	3	74.49	3	8	502.78	6789.97	22706.0
1969	1936	0	1	28	4.92	6	74.49	3	9	594.54	6567.95	23596.1
1970	2116	0	1	29	5.81	9	74.49	3	10	453.06	3104.60	16261.4
1971	2209	0	1	30	5.45	9	74.49	4	11	465.31	2908.01	15456.0
1972	2401	0	1	31	5.83	7	74.49	4	12	73.14	1910.04	8834.0
1973	2401	0	1	32	6.37	7	74.49	3	13	1182.26	6760.95	19231.1
1974	2401	0	1	33	9.10	16	74.49	3	14	913.93	6473.39	22310.6
1975	2401	0	1	34	8.74	11	74.49	3	15	691.92	7377.77	22114.2
1976	2401	0	1	35	7.78	9	74.49	4	16	522.47	9804.54	19291.5
1977	2401	0	1	36	7.39	8	74.49	4	17	1272.08	3947.36	10505.6
1978	2401	0	1	37	8.33	14	74.49	4	18	725.50	7437.62	19806.4

TABLE C.10 COMMODITY TIME SERIES DATA

T=HOG

YR	HHH	SSS	SH	LH	SS	LS	NR	TR	V
1969	386.60	1059.4	65	12	116	95	1158	288	12834
1970	2507.29	4212.7	367	299	564	555	4935	1785	119716
1971	2232.39	8761.6	352	193	1052	1087	8310	2684	191043
1972	4032.44	14975.6	814	304	1357	2795	13738	5270	366378
1973	5758.38	23057.6	1087	824	2678	4974	19253	9563	791823
1974	3454.27	16935.7	859	335	2933	2921	13342	7048	1083512
1975	7313.07	17988.9	1954	436	2116	3763	17033	8269	1426507
1976	5564.94	24082.1	2861	1000	3897	5824	20065	13582	1146815
1977	3419.76	24117.2	680	543	3854	4771	17689	9848	1307712
1978	5445.33	33225.7	1485	482	4601	7401	24702	13969	1765201

YR	TS	HH	ST	VV	CN	FN	CC	CV
1969	1095500	7.94897	6.94030	9.96828	35	2435	0.954491	10.2853
1970	727433	5.66687	5.14561	7.32520	35	2387	0.666275	5.0840
1971	761067	5.82871	4.45276	6.90268	36	2340	0.928251	15.0656
1972	697300	5.14705	3.81909	6.16291	37	2293	0.944369	13.6223
1973	671800	4.75070	3.33704	5.35236	37	2315	0.944266	13.4342
1974	665867	5.25628	3.64590	5.02806	37	2338	0.960555	22.6063
1975	559967	4.32507	3.40547	4.57611	37	2360	0.976400	10.3222
1976	603700	4.12900	3.18090	4.87217	37	2383	0.919901	9.2949
1977	637467	5.22255	3.23601	4.79469	37	2405	0.898041	11.5625
1978	651933	4.77680	2.92431	4.51449	37	2427	0.931567	7.9489

YR	CNSQ	LN	PE	AG	UY	NP	SV	ER	TT	CVSQ	H	S
1969	1225	0	0	3	4.92	10	96.11	2	9	105.787	138.66	1307.3
1970	1225	0	0	4	5.81	9	96.11	2	10	25.847	1155.09	5564.9
1971	1296	0	0	5	5.45	10	96.11	2	11	226.971	956.95	10037.1
1972	1369	0	0	6	5.83	17	96.11	2	12	185.567	1926.03	17082.0
1973	1369	0	0	7	6.37	17	96.11	2	13	180.478	3187.81	25628.2
1974	1369	0	0	8	9.10	23	96.11	2	14	511.046	1975.23	18414.7
1975	1369	0	0	9	8.74	21	96.11	2	15	106.548	3998.92	21303.1
1976	1369	0	0	10	7.78	23	96.11	2	16	66.396	6163.46	27483.5
1977	1369	0	0	11	7.39	21	96.11	2	17	133.692	2008.62	25528.4
1978	1369	0	0	12	8.33	20	96.11	2	18	63.185	3223.47	35447.5

TABLE C.11 COMMODITY TIME SERIES DATA

T=PORK BELLIES

YR	HHH	SSS	SH	LH	SS	LS	NR	TR	V
1969	3994.40	31631.6	1246	186	5853	5487	22854	12772	1670102
1970	3831.74	33650.3	865	511	6097	5987	24022	13460	2287292
1971	5586.21	28993.8	1109	941	5708	4932	21890	12690	1525755
1972	3667.51	31742.5	1209	426	6966	7185	19624	15786	2038653
1973	4072.02	25378.0	1202	322	4148	5350	18428	11022	1639199
1974	3046.57	10493.4	744	325	1880	1802	8789	4751	760160
1975	3098.05	14671.9	774	358	2490	2871	11277	5493	1098338
1976	2787.04	18475.0	589	567	3770	3893	12443	8815	1325382
1977	2228.18	16635.8	842	190	4104	3601	10127	8737	1283297
1978	2467.36	17461.6	862	189	3581	3857	11440	8489	1439587

YR	TS	HH	ST	VV	CN	FN	CC	CV
1969	425800	4.65965	2.52262	4.13898	35	2435	0.629780	5.5767
1970	368000	4.55430	2.29617	3.66924	35	2387	0.524029	4.7615
1971	405722	4.27150	2.56444	4.18173	36	2340	0.943657	25.7256
1972	373889	4.61459	2.37758	3.80332	37	2293	0.877082	17.4795
1973	349389	4.44032	2.54690	3.95674	37	2315	0.862698	12.2971
1974	377306	4.81093	3.55410	4.78671	37	2338	0.941949	27.1572
1975	314278	4.60960	3.01653	4.25611	37	2360	0.843732	12.6517
1976	339444	4.79409	2.85493	4.14357	37	2383	0.954788	16.1566
1977	362528	5.08575	3.03457	4.24311	37	2405	0.865246	17.9551
1978	366917	4.99524	2.99637	4.13838	37	2427	0.870459	15.4263

YR	CNSQ	LN	PE	AG	UY	NP	SV	ER	TT	CVSQ	H	S
1969	1225	0	1	8	4.52	10	96.11	2	9	99.573	2350.62	33275.4
1970	1225	0	1	9	5.81	9	96.11	2	10	22.672	2257.87	35224.1
1971	1296	0	1	10	5.45	10	96.11	2	11	661.807	3347.70	31232.3
1972	1369	0	1	11	5.83	17	96.11	2	12	305.533	2541.11	32868.9
1973	1369	0	1	12	6.37	17	96.11	2	13	150.972	2477.63	26972.4
1974	1369	0	1	13	9.10	23	96.11	2	14	737.511	1762.90	11777.1
1975	1369	0	1	14	8.74	21	96.11	2	15	160.067	1850.38	15919.6
1976	1369	0	1	15	7.78	23	96.11	2	16	261.037	1832.52	19429.5
1977	1369	0	1	16	7.39	21	96.11	2	17	322.386	1586.02	17278.0
1978	1369	0	1	17	8.33	20	96.11	2	18	237.971	1654.31	18274.7

TABLE C.12 COMMODITY TIME SERIES DATA

T=CATTLE

YR	HHH	SSS	SH	LH	SS	LS	NR	TR	V
1969	18913.8	17578.2	6982	2591	3061	5836	18022	18470	624922
1970	16206.1	27559.9	4839	3217	6251	7449	22010	21756	860858
1971	14239.0	13123.0	3709	2351	2527	3058	15717	11645	605717
1972	16092.0	21362.0	4233	2039	2938	5388	22856	14598	961314
1973	24270.2	31895.8	8030	2645	4829	9200	31462	24704	2105272
1974	22204.1	26293.9	7970	1757	4881	6685	27165	21333	2553977
1975	29138.2	23729.8	11699	2007	3519	7643	28000	24868	2263291
1976	35141.1	29640.9	14410	2425	4536	9664	33747	31035	2636475
1977	57544.5	33723.5	24942	3312	5879	10679	46456	44812	2804570
1978	71068.6	75249.4	33388	4808	11020	29423	67679	78639	5552364

YR	TS	HH	ST	VV	CN	FN	CC	CV
1969	662778	3.52760	3.60290	5.57650	28	2435	0.660307	6.2582
1970	691222	3.72935	3.18141	5.29700	28	2387	0.775262	4.4361
1971	702250	3.87782	3.96106	5.66588	29	2340	0.941886	6.7572
1972	746778	3.81566	3.52513	5.26377	30	2293	0.955399	5.0284
1973	702889	3.33081	3.04629	4.41241	30	2315	0.978778	12.5084
1974	648056	3.33884	3.16322	4.13414	30	2338	0.956967	11.0067
1975	569556	2.92029	3.13557	4.12572	30	2360	0.953097	13.9215
1976	671389	2.89622	3.07504	4.13778	30	2383	0.939548	9.9566
1977	690583	2.39797	2.96928	4.10361	30	2405	0.692973	4.0100
1978	740139	2.24224	2.17881	3.46845	30	2427	0.986525	13.1787

YR	CNSQ	LN	PE	AG	UY	NP	SV	ER	TT	CVSQ	H	S
1969	784	0	0	5	4.92	10	83.17	2	9	39.165	14300.7	22191.3
1970	784	0	0	6	5.81	9	83.17	2	10	19.679	12107.4	31658.6
1971	841	0	0	7	5.45	10	83.17	2	11	45.660	9540.9	17821.1
1972	900	0	0	8	5.83	17	83.17	2	12	25.285	10099.4	27354.6
1973	900	0	0	9	6.37	17	83.17	2	13	156.460	16654.7	39511.3
1974	900	0	0	10	9.10	23	83.17	2	14	121.148	15237.8	33260.2
1975	900	0	0	11	8.74	21	83.17	2	15	193.808	20965.0	31903.0
1976	900	0	0	12	7.78	23	83.17	2	16	99.135	25604.9	39177.1
1977	900	0	0	13	7.39	21	83.17	2	17	16.080	42635.5	48632.5
1978	900	0	0	14	8.33	20	83.17	2	18	173.678	55863.5	90454.5

TABLE C.13 COMMODITY TIME SERIES DATA

T=FEEDER CATTLE

YR	HHH	SSS	SH	LH	SS	LS	NR	TR	V
1973	708.4	647.6	4	66	15	49	1222	134	18522
1974	741.6	518.4	63	50	46	33	1068	192	24829
1975	1286.8	1369.2	234	156	190	225	1851	805	31944
1976	1808.7	1359.3	313	178	80	289	2308	860	26597
1977	4784.4	3638.6	1191	546	604	717	5365	3058	119474
1978	11484.1	17063.9	3129	2317	1872	6220	15010	13538	444242

YR	TS	HH	ST	VV	CN	FN	CC	CV
1973	350143	6.20112	6.29091	8.63737	1	146220	0.939741	10.2846
1974	314943	6.04903	6.40768	8.06152	1	137737	0.968776	14.0851
1975	352671	5.60976	5.54739	7.92265	1	136696	0.903232	10.5240
1976	364400	5.30066	5.58755	7.81935	1	132535	0.916942	8.7766
1977	395100	4.40159	4.67829	6.71629	1	131904	0.894173	5.8815
1978	415086	3.55946	3.14954	5.44929	1	127425	0.981659	17.2922

YR	CNSQ	LN	PE	AG	UY	NP	SV	ER	TT	CVSQ	H	S
1973	1	0	0	2	6.37	17	54.53	2	13	105.773	133.08	1222.9
1974	1	0	0	3	9.10	23	54.53	2	14	158.389	208.78	1051.2
1975	1	0	0	4	8.74	21	54.53	2	15	110.755	661.80	1994.2
1976	1	0	0	5	7.78	23	54.53	2	16	77.029	848.71	2319.3
1977	1	0	0	6	7.39	21	54.53	2	17	34.592	2843.38	5579.6
1978	1	0	0	7	8.33	20	54.53	2	18	299.020	8309.40	20238.6

TABLE C.14 COMMODITY TIME SERIES DATA

T=EGGS

YR	HHH	SSS	SH	LH	SS	LS	NR	TR	V
1961	1741.98	14612.0	353	121	1764	2212	11904	4450	489645
1962	557.92	10712.1	128	7	1486	1106	8543	2727	268857
1963	622.32	8327.7	98	33	1001	752	7066	1884	296575
1964	349.55	4872.5	63	3	535	385	4236	986	134590
1965	659.00	2113.0	101	25	185	219	2242	530	63261
1966	1076.59	3403.4	201	16	330	356	3577	903	96224
1967	295.56	2180.4	47	6	161	230	2032	444	71138
1968	237.22	2094.8	55	4	206	315	1752	580	40928
1969	1693.32	6500.7	398	43	651	1042	6060	2134	257256
1970	3981.31	10272.7	855	298	1291	1684	10126	4128	629477
1971	2613.13	8466.9	457	201	1067	1065	8290	2790	523863
1972	1466.67	5393.3	266	112	826	564	5092	1768	374248
1973	4250.94	8621.1	1070	214	1353	1251	8984	3888	652541
1974	4400.76	5727.2	1488	204	944	1258	6234	3894	489140
1975	3173.48	3154.5	963	41	418	580	4326	2002	254507
1976	2793.47	2212.5	800	104	270	446	3386	1620	119533
1977	1867.18	2351.8	408	89	224	402	3096	1123	147197
1978	2008.59	1346.4	285	79	139	105	2747	608	98506

YR	TS	HH	ST	VV	CN	FN	CC	CV
1961	344011	5.28058	3.11543	5.16274	1	11894	0.54193	18.6723
1962	353161	6.44888	3.46475	5.79116	1	11394	0.74485	12.7101
1963	352778	6.33837	3.72236	5.65028	1	10894	0.34893	13.4244
1964	362306	6.94264	4.29535	6.51023	1	10394	0.49782	12.1098
1965	364211	6.31295	5.14381	7.27123	1	9894	0.57148	12.2564
1966	367817	5.83086	4.67351	6.86132	1	9394	-0.17134	11.2336
1967	385156	7.17177	5.16844	7.20975	1	8894	0.89862	22.0444
1968	315537	7.19229	5.00817	7.56340	1	8394	0.79602	8.4588
1969	312583	5.21275	3.85195	5.71296	1	7894	0.92529	12.8467
1970	317231	4.36539	3.39722	4.82823	1	7394	0.97330	20.2591
1971	324792	4.81456	3.62061	5.03694	1	6894	0.87243	13.8295
1972	256367	5.15787	3.84018	5.13729	1	6394	0.77723	8.4206
1973	244589	4.03491	3.30949	4.52944	1	5894	0.94161	20.3372
1974	243037	3.99316	3.72413	4.81394	1	5394	0.97284	17.0277
1975	239356	4.30977	4.31585	5.45582	1	4894	0.94658	10.6460
1976	238930	4.43712	4.67273	6.20369	1	4394	0.77703	8.9241
1977	239259	4.84528	4.61248	6.00477	1	3894	0.95107	11.5960
1978	246667	4.81057	5.21324	6.44587	1	3394	0.66144	7.8154

YR	CNSQ	LN	PE	AG	UY	NP	SV	ER	TT	CVSQ	H	S
1961	1	0	0	42	3.24	3	80.12	2	1	348.655	819.02	15535.0
1962	1	0	0	43	3.46	3	80.12	2	2	161.547	237.33	11032.7
1963	1	0	0	44	3.39	2	80.12	2	3	180.214	234.42	8715.6
1964	1	0	0	45	3.27	2	80.12	2	4	146.646	119.54	5102.5
1965	1	0	0	46	3.24	2	80.12	2	5	150.219	227.91	2544.1
1966	1	0	0	47	3.90	2	80.12	2	6	126.194	390.26	4085.7
1967	1	0	0	48	4.19	3	80.12	2	7	485.956	96.50	2379.5
1968	1	0	0	49	4.50	4	80.12	2	8	29.798	103.33	2228.7
1969	1	0	0	50	4.92	10	80.12	2	9	165.038	767.15	7426.9
1970	1	0	0	51	5.81	9	80.12	2	10	410.431	1972.09	12281.9
1971	1	0	0	52	5.45	10	80.12	2	11	191.255	1150.31	9929.7
1972	1	0	0	53	5.83	17	80.12	2	12	70.907	658.58	6201.4
1973	1	0	0	54	6.37	17	80.12	2	13	413.601	2180.17	10691.8
1974	1	0	0	55	5.10	23	80.12	2	14	289.942	2733.46	7394.5
1975	1	0	0	56	8.74	21	80.12	2	15	113.336	1690.36	4637.6
1976	1	0	0	57	7.78	23	80.12	2	16	79.639	1515.46	3490.5
1977	1	0	0	58	7.39	21	80.12	2	17	143.905	861.71	3357.3
1978	1	0	0	59	8.33	20	80.12	2	18	61.080	662.04	2693.0

TABLE C.15 COMMODITY TIME SERIES DATA

T=FCOJ

YR	HHH	SSS	SH	LH	SS	LS	NR	TR	V
1969	8085.3	2932.70	1756	2407	956	554	5345	5673	179906
1970	4098.9	2717.09	1159	603	817	351	3886	2930	86870
1971	6006.4	2543.61	1496	1536	790	494	4234	4316	116879
1972	7184.2	2787.75	1718	2194	937	581	4542	5430	132585
1973	6009.3	2664.67	1922	1118	611	737	4286	4388	119300
1974	6806.7	2357.34	2648	866	387	830	4433	4731	139479
1975	5417.1	1906.86	2436	556	369	825	2738	4586	76115
1976	7947.7	1120.35	3105	2031	247	477	3208	5860	74339
1977	12042.4	6253.62	3760	3224	1446	2204	7702	10634	255164
1978	18382.5	6642.54	5475	5827	1998	2086	9639	15386	364912

YR	TS	HH	ST	VV	CN	FN	CC	CV
1969	37115.1	1.27827	2.45579	3.92347	39	53	0.172247	12.6954
1970	43304.4	2.25810	2.70389	4.81725	37	51	0.331810	25.3614
1971	49328.5	1.97584	2.91198	4.64930	38	47	0.656426	27.0827
1972	52648.7	1.84504	2.88400	4.58775	44	42	0.323644	6.1671
1973	62913.5	2.24805	3.11841	4.87397	39	36	0.646788	16.7234
1974	68366.1	2.20210	3.33225	4.80023	42	51	-0.087465	5.5467
1975	71591.9	2.50273	3.59853	5.45594	45	36	-0.065882	17.2840
1976	73243.9	2.10606	4.16474	5.50255	41	42	-0.092363	10.9204
1977	66537.0	1.50967	2.25885	4.16185	41	56	0.654622	25.0133
1978	64515.6	0.92013	2.16476	3.76583	40	53	0.544110	6.5515

YR	CNSQ	LN	PE	AG	UY	NP	SV	ER	TT	CVSQ	H	S
1969	1521	0	1	3	4.92	4	44.47	4	9	161.174	6182.5	4835.47
1970	1369	0	1	4	5.81	4	44.47	5	10	643.200	2766.6	4049.43
1971	1444	0	1	5	5.45	6	44.47	3	11	733.475	4533.5	4016.54
1972	1936	0	1	6	5.83	5	44.47	3	12	38.033	5693.8	4278.18
1973	1521	0	1	7	6.37	4	44.47	4	13	279.671	4542.1	4131.87
1974	1764	0	1	8	9.10	5	44.47	4	14	30.788	5213.9	3950.14
1975	2025	0	1	9	8.74	5	44.47	4	15	298.736	4660.1	2663.94
1976	1681	0	1	10	7.78	5	44.47	3	16	119.255	6953.0	2115.03
1977	1681	0	1	11	7.39	4	44.47	3	17	625.664	9917.6	8418.38
1978	1600	0	1	12	8.33	3	44.47	3	18	42.922	15655.2	9369.75

TABLE C.16 COMMODITY TIME SERIES DATA

T=COTTON

YR	HHH	SSS	SH	LH	SS	LS	NR	TR	V
1961	4495.6	2464.4	1080	580	520	390	4390	2570	28780
1962	6308.4	1911.6	1850	460	240	460	5210	3010	34930
1963	3876.1	1655.9	373	671	286	160	4042	1490	30370
1964	1096.3	1321.7	16	125	67	103	2107	311	9456
1965	386.0	386.0	1	1	1	1	768	4	2048
1966	207.0	207.0	1	1	1	1	410	4	664
1967	0.0	0.0	0	0	0	0	0	1	1
1968	6701.2	2320.8	2847	531	391	510	6743	4279	197419
1969	8686.7	3117.3	2784	1630	875	709	5806	5998	154188
1970	3617.3	986.7	1223	412	178	268	2523	2081	33042
1971	8059.9	1652.1	3294	448	217	550	5203	4509	165516
1972	24494.0	7712.0	8365	5432	1771	2573	14065	18141	410756
1973	25116.1	4613.9	9491	7629	1303	1842	9465	20265	433638
1974	28077.9	6076.1	10589	11093	2118	2574	7780	26374	400927
1975	21689.8	4788.2	7619	6591	1406	1731	9131	17347	417801
1976	28603.7	10906.3	13182	5119	2140	4838	14231	25279	730990
1977	38638.2	11645.8	15703	11778	3297	4985	14524	35760	902421
1978	47385.1	11211.9	20286	12678	3063	4736	17838	40763	947327

YR	TS	HH	ST	VV	CN	FN	CC	CV	CNSC
1961	220550	3.87244	4.48292	7.5574	28	266	0.41271	2.4804	784
1962	216820	3.50766	4.72226	7.3465	29	247	0.14438	1.1293	841
1963	227990	4.05732	4.91768	7.5368	30	229	0.12011	1.3817	900
1964	266280	5.48882	5.30063	8.8592	30	226	-0.13821	0.3885	900
1965	277420	6.57606	6.57606	10.4301	30	223	-0.15432	1.8222	900
1966	252610	7.25317	7.25317	11.6098	30	221	0.56820	1.1650	900
1967	268280	.	.	18.0212	30	218	0.00000	9.6697	900
1968	158980	3.08503	4.43955	5.5254	31	212	0.60192	5.5715	961
1969	175600	2.95568	4.01333	5.6480	32	207	0.91836	5.6119	1024
1970	165340	3.80016	5.11538	7.1309	33	201	-0.09907	1.8277	1089
1971	161080	2.94366	4.56957	5.4902	32	196	0.68369	3.2022	1024
1972	145520	1.59758	2.88309	4.4724	31	190	0.96218	11.8699	961
1973	165040	1.71759	3.54876	4.5449	31	194	0.84696	18.1765	961
1974	167500	1.60252	3.27967	4.6390	31	198	0.96182	14.9782	961
1975	150000	1.77761	3.41203	4.4859	31	203	0.94883	11.1824	961
1976	137760	1.33925	2.45369	3.8311	31	207	0.99182	12.9973	961
1977	140730	0.97163	2.40552	3.6372	31	211	0.96138	6.6027	961
1978	170020	0.95079	2.65072	3.7812	31	215	0.97317	7.0564	961

YR	LN	PE	AG	UY	NP	SV	ER	TT	CVSQ	H	S
1961	0.938385	1	91	3.24	2	83.64	6	1	6.152	2707.0	4253.0
1962	0.953540	1	92	3.46	2	83.64	6	2	1.275	3774.1	4445.9
1963	0.953232	1	93	3.39	2	83.64	6	3	1.909	1806.8	3725.2
1964	0.962454	1	94	3.27	2	83.64	6	4	0.151	263.9	2154.1
1965	0.939018	1	95	3.24	2	83.64	6	5	3.320	4.0	768.0
1966	0.942999	1	96	3.90	2	83.64	6	6	1.357	4.0	410.0
1967	0.882515	1	97	4.19	2	83.64	6	7	93.503	1.0	1.0
1968	0.811963	1	98	4.50	4	83.64	4	8	31.041	5444.6	5577.4
1969	0.864024	1	99	4.92	4	83.64	4	9	31.494	6585.1	5218.9
1970	0.906721	1	100	5.81	4	83.64	5	10	3.341	2531.0	2073.0
1971	0.856409	1	101	5.45	6	83.64	3	11	10.254	5746.7	3965.3
1972	0.661886	1	102	5.83	5	83.64	3	12	140.894	19822.4	12383.6
1973	0.660957	1	103	6.37	4	83.64	4	13	330.385	22570.4	7159.6
1974	0.359066	1	104	9.10	5	83.64	4	14	224.346	26621.0	7533.0
1975	0.569197	1	105	8.74	5	83.64	4	15	125.046	19110.4	7367.6
1976	0.651908	1	106	7.78	5	83.64	3	16	168.930	24892.8	14617.2
1977	0.537252	1	107	7.39	4	83.64	3	17	43.595	35414.7	14869.3
1978	0.851614	1	108	8.33	3	83.64	3	18	49.793	42998.2	15602.8

Table C.17--A list of the variables and their corresponding symbols

Symbol	Variable
YR	Year
HHH	Actual hedging (Scheme 1)
SSS	Actual speculation (Scheme 1)
SH	Reported short hedging
LH	Reported long hedging
SS	Reported short speculation
NR	Total nonreporting open interest
TR	Total reporting open interest
V	Volume
TS	Total supply
HH	Hedging in percent (Scheme 1)
ST	Speculation in percent (Scheme 1)
VV	Volume in percent
CN	Concentration
FN	Firm numbers
CC	Correlation coefficient
CV	Coefficient of variation
CNSQ	Concentration squared
LN	Loan rate
PE	Perishability
AG	Age
UY	Utility yield
NP	Number of pits
SV	Spreading variable
ER	Exchange rank
TT	Time trend
CVSQ	Coefficient of variation squared
H	Actual hedging (Scheme 2)
S	Actual speculation (Scheme 2)

APPENDIX D

THE CONCENTRATED LIKELIHOOD FUNCTION

The goal of this appendix is to derive the concentrated likelihood function used in stage two of the estimation procedure. The derivation begins with the log likelihood function. Under the assumption of normality the function is given as follows:

$$(D.1) \quad L = -\frac{NT}{2}\log(2\pi) - \frac{1}{2}\log|\Sigma| - \frac{1}{2}(Y-XB)\,\Sigma^{-1}\,(Y-XB)$$

where N = the number of cross-sections

T = the number of observations per cross-section

Σ = the variance-covariance matrix of the regression model given by $Y = XB + U$.

In the variance-component models Σ has the following form:

$$(D.2) \quad \Sigma = \sigma_u^2 \begin{bmatrix} A_1 & & \\ & A_2 & \\ & & \ddots A_N \end{bmatrix}$$

where $$A_i = \begin{bmatrix} 1 & \rho & \rho\cdots\rho \\ \rho & 1 & \rho\cdots \\ \vdots & & \ddots 1 \end{bmatrix},$$

$$\rho = \sigma_\varepsilon^2 / \sigma_u^2$$

Assuming that N = 2 and T = 2 for illustrative purposes, Σ can be explicitly written as follows:

$$(D.3) \quad \Sigma = \sigma_u^2 \begin{bmatrix} 1 & \rho & 0 & 0 \\ \rho & 1 & 0 & 0 \\ 0 & 0 & 1 & \rho \\ 0 & 0 & \rho & 1 \end{bmatrix}$$

The determinate of Σ is the product of the block matrices which comprise Σ. Mathematically, this is given by:

$$(D.4) \quad |\Sigma| = [(1-\rho^2)]^2[\sigma_u^2]^4$$

Equation D.4 can be generalized as follows:

$$(D.5) \quad |\Sigma| = [(1-\rho)(1+\rho)]^{N}[\sigma_u^2]^{NT}.$$

Noting that when N = 3 and T = 3 the determinate of Σ is given by

$$(D.6) \quad |\Sigma| = [(1-\rho)^2(1+2\rho)]^{N}[\sigma_u^2]^{NT}.$$

A further generalization of $|\Sigma|$ under the variance-component model yields the following:

$$(D.7) \quad |\Sigma| = [(1-\rho)^{(T-1)}(1+(T-1)\rho)]^{N}[\sigma_u^2]^{NT}.$$

Substituting D.7 into D.1 gives

$$(D.8) \quad L = \frac{-NT}{2}\log(2\pi) - \frac{1}{2}[N(T-1)\log(1-\rho) + N\log(1+(T-1)\rho) + NT\log(\sigma_u^2)] - \frac{1}{2}(Y-X\beta)'\Sigma^{-1}(Y-X\beta).$$

Differentiating D.8 with respect to σ_u^2 gives the following result:

$$(D.9) \quad \frac{\partial L}{\partial \sigma_u^2} = \frac{-1}{2}NT(\sigma_u^2)^{-1} - \frac{1}{2}(\sigma_u^2)^{-1}(Y-X\beta)'\Sigma^{-1}(Y-X\beta)$$

Setting D.9 equal to zero yields:

$$(D.10) \quad NT = (Y-X\beta)'\Sigma^{-1}(Y-X\beta)$$

Substituting D.10 into D.8 yields the concentrated likelihood function given as follows:

$$(D.11) \quad L = -NT\log(2\pi) - \frac{1}{2}[N(T-1)\log(1-\rho) + N\log(1+(T-1)\rho) + NT\log(\sigma_u^2)].$$

Rewritting D.11 gives:

$$(D.12) \quad -2L = NT\log(2\pi) + NT\log(\sigma_u^2(1-\rho)) + N\log\left(\frac{1-\rho+T\rho}{1-\rho}\right)$$

If the number of observations per cross-section depends on the cross-section then D.12 is expressed as follows:

$$(D.13) \quad -2L = \sum_{i=1}^{N} T_i\log(2\pi) + \sum_{i=1}^{N} T_i\log(\sigma_u^2(1-\rho) + \sum_{i=1}^{N}\log\left(\frac{1-\rho+T_i\rho}{1-\rho}\right)$$

For programming purposes the following function is used:

$$(D.14) \quad CON = \sum_{i=1}^{N} T_i \log(\sigma_u^2(1-\rho)) + \sum_{i=1}^{N} \log\left(\frac{1-\rho+T_i\rho}{1-\rho}\right)$$

The ρ that minimizes CON maximizes -2L. Although CON is not the concentrated likelihood function, using CON for programming does not cause any problems and is easier to implement.

The equation given by D.13 is the concentrated likelihood function used in the econometric analysis of this research. Recall that in the second stage of the estimation procedure the function is evaluated iteratively over values of ρ. The ρ which maximizes D.13 is the ML estimate of ρ. Furthermore, the corresponding estimates of β and σ_u^2 are ML estimates as well.

APPENDIX E

MODEL RESULTS

The results corresponding to each of the three stages for all of the models estimated are given below. Four models were estimated. Two functional form specifications were tested, and two allocation schemes were used. The logistic and exponential specifications were tested under both allocation schemes yielding four empirical models.

Table E.1--First stage estimates of the logistic model using Scheme 1 allocation

Variables[a]	Activity Equations		
	Hedging	Speculation	Volume
Concentration (CN)	-.040448 (-1.83)	-.007441 (-.35)	.020590 (.82)
Concen. squared (CN^2)	-.000592 (-1.93)	-.000781 (-2.68)	-.000793 (-2.28)
Firm numbers (FN)	.000004 (1.06)	.000014 (3.46)	.000017 (3.46)
Correlation coef.	-1.378133 (-4.55)	-.147565 (-.51)	-1.074588 (-3.13)
Coef. of variation (CV)	.016251 (.56)	-.099583 (-3.63)	-.073313 (-2.24)
Coef. of var. squared (CV^2)	-.000329 (-.47)	-.001623 (-2.44)	.001317 (1.66)
Loan rate (LN)	.379007 (1.01)	-.036389 (-.10)	-.057175 (-.13)
Perishability (FE)	-.690551 (-1.89)	-.257582 (-.74)	-.916709 (-2.21)
Maturation (AG)	-.014722 (-2.48)	.000343 (.06)	.009559 (1.42)
Stock yield (UY)	-.109570 (-1.11)	.145099 (1.55)	-.105377 (-.94)
Spreading (SV)	.047537 (5.19)	.036645 (4.22)	.003634 (.35)
Number of pits (NP)	.039030 (1.65)	-.027970 (-1.24)	.026332 (.98)
Exchange rank (ER)	.190677 (2.97)	.471225 (7.76)	.207927 (2.87)
Time trend (TT)	-.002717 (-.07)	-.016570 (-.50)	-.037237 (-.94)
Intercept	2.983197 (4.12)	1.019839 (1.48)	6.838153 (8.36)
R^2	.62	.68	.53
df	229	229	229
MSE	1.05	.94	1.35
F	26.77	36.20	18.70

[a]See Table 4.2 and Appendix A.

[b]Statistics shown in parentheses are t-values.

Table E.2--Second stage estimates of the logistic model using Scheme 1 allocation

Variables	Activity Equations		
	Hedging (equation 5.1)	Speculation (equation 5.2)	Volume (equation 5.3)
Hedging	--	--	.630700 (3.21)
Speculation	--	--	.190724 (.99)
Volume	1.351200 (5.05)	1.045328 (6.76)	--
Concentration	-.070274 (-1.28)	--	--
Concen. squared	.001610 (2.15)	--	--
Firm numbers	-.000015 (-1.54)	--	--
Correlation coef.	.240274 (.56)	--	--
Coef. of variation	.128447 (3.57)	.057171 (2.01)	--
Coef. of var. squared	-.002279 (-.3.05)	-.000989 (-1.55)	--
Loan rate	.201820 (.50)	--	--
Perishability	-1.000636 (-1.30)	.154810 (.30)	.103580 (.14)
Maturation	-.003671 (-.52)	.007166 (1.27)	--
Stock yield	--	.144631 (2.91)	--
Spreading	--	.016814 (1.31)	-.010429 (-.67)
Number of pits	--	--	-.004222 (-.18)
Exchange rate	--	--	.422173 (2.93)
Time trend	--	--	-.049303 (-2.18)
Intercept	-3.628200 (-1.51)	-4.996861 (-2.60)	2.818612 (1.88)
R^2	.59	.71	.74
df	233	236	236
ρ	211.015	212.151	279.379

[a]CON is the value of the concentrated likelihood function.

Table E.3--Third stage estimates of the logistic model using Scheme 1 allocation (see equations 5.1, 5.2, and 5.3)

Variables[a]	Activity Equations[b]		
	Hedging	Speculation	Volume
Hedging	--	--	.837352 (6.34)
Speculation	--	--	-.057400 (-.40)
Volume	.803818 (4.37)	.925210 (7.59)	--
Concentration	-.064293 (-2.18)	--	--
Concen. squared	.000551 (1.34)	--	--
Firm numbers	-.000013 (-2.22)	--	--
Correlation coef.	-.294997 (-1.06)	--	--
Coef. of variation	.111845 (4.62)	.089330 (4.47)	--
Coef. of var. sq.	-.002115 (-4.49)	-.001709 (-4.02)	--
Loan rate	.359738 (1.64)	--	--
Perishability	.040022 (.06)	.452820 (1.05)	1.001283 (1.68)
Maturation	-.024194 (-5.13)	.003083 (.83)	--
Stock yield	--	.106882 (3.05)	--
Spreading	--	-.001704 (-.19)	-.051425 (-4.98)
Number of pits	--		-.001967 (-.16)
Exchange rank	--		.148609 (1.66)
Time trend	--		-.040626 (-2.81)
Weighted R^2 for system = .6002			
Weighted MSE for system = .9089			
Degrees of freedom = 705			

[a]For all data included in the estimation see Appendix C.

[b]Note that in Chapter 4 the exogenous values were expressed according to a logistic model. Hence, all results here correspond to this specification.

Table E.4--First stage estimates of the logistic model using Scheme 2 allocation

Variable	Activity equations		
	Hedging	Speculation	Volume
Concentration	-.052769 (-1.98)	-.008708 (-.44)	.020592 (.82)
Concen. squared	-.000496 (-1.34)	-.000717 (-2.61)	-.000793 (-2.28)
Firm numbers	.000005 (.94)	.000014 (3.56)	.000017 (3.46)
Correlation coef.	-1.732716 (-4.74)	-.194850 (-.71)	-1.074558 (-3.13)
Coef. of variation	.014937 (.42)	-.078459 (-3.02)	-.073313 (-2.24)
Coef. of var. sq.	-.000268 (-.31)	.001236 (1.97)	.001317 (1.66)
Loan rate	.308166 (.68)	-.055890 (-.16)	-.057175 (-.13)
Perishability	-.904098 (-2.05)	-.350616 (-1.07)	-.916709 (-2.21)
Age	-.013683 (-1.91)	-.000972 (-.18)	.009559 (1.42)
Utility yield	-.172084 (-1.45)	.131579 (1.49)	-.105377 (-.94)
Spreading	.045020 (4.16)	.041968 (5.11)	.003634 (.35)
Number of pits	.060629 (2.12)	-.037304 (-1.76)	.026332 (.98)
Exchange rank	.250417 (3.24)	.387543 (6.75)	.207927 (2.87)
Time trend	.000600 (.01)	-.011363 (-.36)	-.037237 (-.94)
Intercept	4.133348 (4.73)	.562178 (.86)	6.838153 (8.36)
R^2	.60	.66	.53
df	229	229	229
MSE	1.53	.84	1.35
F	25.53	32.52	18.70

[a]See equations 4.2 and 4.3.

Table E.5--Second stage estimates of the logistic model using Scheme 2 allocation

Variable	Activity Equations		
	Hedging	Speculation	Volume
Predicted hedging	--	--	.572107 (3.46)
Predicted speculation	--	--	.182917 (.83)
Predicted volume	1.787732 (5.40)	1.004313 (6.82)	--
Concentration	-.084705 (-1.11)	--	--
Concen. squared	.002200 (2.21)	--	--
Firm numbers	-.000016 (-1.15)	--	--
Correlation coef.	.395528 (.76)	--	--
Coef. of variation	.158803 (3.67)	.066035 (2.44)	--
Coef. of var. squared	-.002759 (-3.08)	-.001152 (-1.90)	--
Loan rate	-.004050 (.00)	--	--
Perishability	-1.217826 (-1.14)	.109887 (.23)	.172561 (.24)
Age	-.000051 (-.00)	.004662 (.86)	--
Utility yield	--	.134079 (2.84)	--
Spreading	--	.023350 (1.92)	-.006951 (-.49)
Number of pits	--	--	-.008568 (-.35)
Exchange rank	--	--	.413210 (2.94)
Time trend	--	--	-.044654 (-1.92)
Intercept	-6.073616 (-1.97)	-5.493752 (-3.00)	2.544254 (1.69)
R^2	.52	.70	.74
df	233	236	236
ρ	.6	.3	.4
CON	283.700	195.164	277.682

Table E.6--Third stage estimates of the logistic model using Scheme 2 allocation[a]

Variables	Activity Equations		
	Hedging	Speculation	Volume
Hedging	--	--	.717963 (7.11)
Speculation	--	--	-.080929 (-.55)
Volume	1.184964 (5.03)	.874668 (7.86)	--
Intercept	-.853657 (-.40)	-3.947649 (-3.14)	5.158823 (4.95)
Concentration	-.065060 (-1.38)	--	--
Concen. squared	.000912 (1.48)	--	--
Firm numbers	-.000016 (-1.77)	--	--
Correlation coef.	-.131502 (-.37)	--	--
Coef. of variation	.135020 (4.55)	.094663 (5.86)	--
Coef. of var. squared	-.002470 (-4.18)	-.001790 (-5.19)	--
Loan rate	.227346 (.76)		--
Perishability	-.259098 (-.29)	.357077 (.90)	.915462 (1.58)
Maturation	-.024710 (-3.66)	-.000036 (-.01)	--
Stock yield	--	.089167 (2.78)	--
Spreading	--	.014458 (1.71)	-.031522 (-2.87)
Number of pits	--	--	-.000592 (-.04)
Exchange rank	--	--	.102149 (1.35)
Time trend	--	--	-.045641 (-3.39)
Weighted R^2 for system = .6039			
Weighted MSE for system = .9062			
Degrees of freedom = 705			

[a]See equations 4.2 and 4.3.

Table E.7--First stage estimates of the exponential model using Scheme 1 allocation

Variable	Activity Equations		
	Hedging	Speculation	Volume
Concentration	.043094 (2.02)	.011537 (.57)	-.019641 (-.79)
Concen. squared	.000475 (1.60)	.000638 (2.29)	.000767 (2.22)
Firm numbers	-.000004 (-1.05)	-.000014 (-3.56)	-.000017 (-3.46)
Correlation coef.	1.317241 (4.50)	.180244 (.65)	1.075128 (3.15)
Coef. of variation	-.019164 (-.68)	.088156 (3.36)	.071570 (2.19)
Coef. of var. squared	.000404 (.59)	-.001413 (-2.23)	-.001282 (-1.62)
Loan rate	-.373347 (-1.03)	-.045532 (-.13)	.039404 (.09)
Perishability	.656699 (1.86)	.243469 (.73)	.913263 (2.21)
Age	.014433 (2.51)	.000037 (.00)	-.009438 (-1.41)
Utility yield	.111729 (1.17)	-.131810 (-1.48)	.105468 (.95)
Spreading	-.045761 (-5.17)	-.035828 (-4.32)	-.003664 (-.35)
Number of pits	-.034034 (-1.49)	.025970 (1.21)	-.026276 (-.98)
Exchange rank	-.177152 (-2.86)	-.460567 (-7.95)	-.206108 (-2.85)
Time trend	-.002934 (-.08)	.014275 (.45)	.036451 (.93)
Intercept	-3.097455 (-4.44)	-1.094767 (-1.67)	-6.829074 (-8.39)
R^2	.60	.68	.53
df	229	229	229
MSE	.98	.86	1.33
F	25.37	35.38	18.46

Table E.8--Second stage estimates of the exponential model using Scheme 1 allocation

Variable	Activity Equations		
	Hedging	Speculation	Volume
Predicted hedging	--	--	.652367 (3.16)
Predicted speculation	--	--	.242933 (1.17)
Predicted volume	1.199064 (4.69)	1.021793 (6.77)	--
Concentration	.063829 (1.39)	--	--
Concen. squared	-.001328 (-2.02)	--	--
Firm numbers	.000014 (1.71)	--	--
Correlation coef.	-.138087 (-.33)	--	--
Coef. of variation	-.114529 (-3.30)	-.057962 (-2.11)	--
Coef. of var. squared	.002035 (2.81)	.001006 (1.64)	--
Loan rate	-.214682 (-.54)	--	--
Perishability	.900269 (1.37)	-.211201 (-.43)	-.157795 (-.22)
Age	.005103 (.84)	-.006370 (-1.16)	--
Utility yield	--	-.139207 (-2.90)	--
Spreading	--	-.016795 (-1.36)	.011047 (.72)
Number of pits	--	--	.001480 (.06)
Exchange rank	--	--	-.402415 (-2.74)
Time trend	--	--	.050622 (2.30)
Intercept	2.459009 (1.11)	4.791114 (2.57)	-2.549395 (-1.68)
R^2	.66	.73	.74
df	233	236	236
ρ	.4	.3	.4
CON	201.648	200.574	276.837

Table E.9--Third stage estimates of the exponential model using Scheme 1 allocation

Variable	Activity Equations		
	Hedging	Speculation	Volume
Predicted hedging	--	--	.847094 (6.15)
Predicted speculation	--	--	.038299 (.24)
Predicted volume	.707824 (3.95)	.904446 (7.60)	--
Concentration	.072354 (2.90)	--	--
Concen. squared	-.000518 (-1.41)	--	--
Firm numbers	.000013 (2.42)	--	--
Correlation coef.	.339280 (1.25)	--	--
Coef. of variation	-.099013 (-4.20)	-.085334 (-4.45)	--
Coef. of var. squared	.001900 (4.13)	.001661 (4.07)	--
Loan rate	-.339729 (-1.58)	--	--
Perishability	-.169374 (-.32)	-.474483 (-1.12)	--
Age	.023429 (5.64)	-.002885 (-.81)	-1.071719 (-1.77)
Utility yield	--	-.104949 (-3.11)	--
Spreading	--	.006071 (.70)	.060007 (5.71)
Number of pits	--	--	-.003555 (-.31)
Exchange rank	--	--	-.107233 (-1.16)
Time trend	--	--	.045004 (3.23)
Intercept	-1.932415 (-1.31)	2.234582 (1.68)	-6.801676 (-6.93)

Weighted R^2 = .59
Weighted MSE = .905907
Degrees of freedom = 705

Table E.10--First stage estimates of the exponential model using Scheme 2 allocation

Variables	Activity Equations		
	Hedging	Speculation	Volume
Concentration	-.055860 (-4.91)	.012414 (.66)	-.019641 (-.79)
Concen. squared	.000382 (1.05)	.000569 (2.19)	.000767 (2.22)
Firm numbers	-.000005 (-.94)	-.000014 (-3.69)	-.000017 (-3.46)
Correlation coef.	1.669232 (4.67)	.233664 (.91)	1.075128 (3.15)
Coef. of variation	-.016719 (-.48)	.065502 (2.67)	.071570 (2.19)
Coef. of var. squared	.000322 (.38)	-.001000 (-1.68)	-.001282 (-1.62)
Loan rate	-.295422 (-.66)	-.036007 (-.11)	.039404 (.09)
Perishability	.866591 (2.01)	.341392 (1.10)	.913263 (2.21)
Age	.013498 (1.92)	.001242 (.24)	-.009438 (-1.41)
Utility yield	.172681 (1.48)	-.116507 (-1.40)	.105468 (.95)
Spreading	-.045029 (-4.16)	-.040380 (-5.21)	-.003664 (-.35)
Number of pits	-.055328 (-1.98)	.034769 (1.73)	-.026276 (-.98)
Exchange rank	-.238294 (-3.15)	-.375763 (-6.93)	-.206108 (-2.85)
Time trend	-.006007 (-.14)	.008994 (.30)	.036451 (.93)
Intercept	-4.189396 (-4.91)	-.692366 (-1.13)	-6.829074 (-8.39)
R^2	.59	.65	.53
df	229	229	229
MSE	1.47	.75	1.33
F	24.28	31.62	18.46

Table E.11--Second stage estimates of the exponential model using Scheme 2 allocation

Variables	Activity Equations		
	Hedging	Speculation	Volume
Predicted hedging	--	--	.582556 (3.35)
Predicted speculation	--	--	.242675 (.99)
Predicted volume	1.622981 (5.09)	.979412 (7.28)	--
Concentration	.081966 (1.27)	--	--
Concen. squared	-.001936 (-2.20)	--	--
Firm numbers	.000016 (1.38)	--	--
Correlation coef.	-.259529 (-.51)	--	--
Coef. of variation	-.143099 (-3.40)	-.062253 (-2.42)	--
Coef. of var. squared	.002475 (2.83)	.001114 (1.91)	--
Loan rate	.000587 (.00)	--	--
Perishability	1.090417 (1.20)	-.186494 (-.47)	-.232296 (-.33)
Age	.002508 (.30)	-.003527 (-.78)	--
Utility yield	--	-.135688 (-3.09)	--
Spreading	--	-.023268 (-2.33)	.007956 (.50)
Number of pits	--	--	.005204 (.21)
Exchange rank	--	--	-.395229 (-2.76)
Time trend	--	--	.046388 (2.04)
Intercept	4.677951 (1.64)	5.266289 (1.91)	-2.331705 (-1.54)
R^2	.58	.79	.74
df	233	236	236
ρ	.5	.2	.4
CON	275.743	181.289	275.227

Table E.12--Third stage estimates of the exponential model using Scheme 2 allocation

Variables	Activity Equation		
	Hedging	Speculation	Volume
Predicted hedging	--	--	.715046 (6.73)
Predicted speculation	--	--	.071286 (.43)
Predicted volume	1.055839 (4.59)	.881626 (8.74)	--
Concentration	.078880 (1.97)	--	--
Concen. squared	-.000863 (-1.57)	--	--
Firm numbers	.000015 (1.92)	--	--
Correlation coef.	.238551 (.68)	--	--
Coef. of variation	-.115765 (-3.99)	-.086317 (-5.56)	--
Coef. of var. squared	.002148 (3.71)	.001681 (4.99)	--
Loan rate	-.170015 (-.57)	--	--
Perishability	.041423 (.05)	-.408572 (-1.27)	-1.048450 (-1.81)
Age	.023838 (4.04)	-.000362 (-.13)	--
Utility yield	--	-.098304 (-3.20)	--
Spreading	--	-.013035 (-1.88)	.040624 (3.68)
Number of pits	--	--	-.005350 (-.42)
Exchange rank	--	--	-.044575 (-.56)
Time trend	--	--	.049019 (3.65)
Intercept	-.415625 (-.21)	3.825355 (3.45)	-5.471027 (-5.29)

Weighted R^2 = .65
Weighted MSE = .909189
Degrees of freedom = 705

APPENDIX F

THE ESTIMATION PROCEDURE

Below the program used to estimate equations 5.1, 5.2, and 5.3 is presented. It illustrates the estimation procedure used for a simultaneous equation model with an error component. The error component arises from specific cross-sectional ignorance. This estimator is unusual because the inclusion of the cross-sectional error component in a simultaneous equation model.

```
*************************************************
*** PROGRAM FOR BEHRS DISSERTATION FOR       ***
*** POOLING CROSS SECTIONAL AND TIME SERIES ***
*** DATA.    "WPPOOL"  40011267,3 "VEGMKT"    ***
*************************************************;
*********************************************************
**** POOLING CROSS SECTIONAL AND TIME SERIES DATA ****
**** WITH A THREE EQUATION SIMULTANEOUS SYSTEM     ****
**** USE THE FOLLOWING STEP CHANGES                ****
****   STEP 1   DEFINE NO OF VARIABLES             ****
****   STEP 2   DEFINE INITIAL OLS MODEL           ****
****   STEP 3   DEFINE VARIALBES IN THE MODEL      ****
****   STEP 4   DEFINE OUTPUT COLUMNS              ****
****   STEP 5   DEFINE SEEMINGLY UNRELATED MODEL   ****
*********************************************************;
*************************************************
*************  VARIABLE DEFINITION  *************
***   TS=TOTAL SUPPLY(TS)   ***********************
***   CN=CONCENTRATION(CN)  ***********************
***   FN=NUMBER OF FIRMS(FN)     ******************
***   RR=RISK RATIO(RR)  **************************
***   CV=SEASONAL COEFICIENT OF VAR(CV)  **********
***   TV=TOTAL COEFICIENT OF VARIATION(TV)  *******
***   LN=LOAN RATE AS % OF MEAN(LN)  **************
***   PE=DEGREE OF PERISHABILITY(PE)  *************
***   AG=AGE OF MARKET(AG)  ***********************
***   IR=INTEREST RATE(IR)  ***********************
***   NP=NUMBER OF PITS ON EXCHANGE FLOOR(NP)  ****
***   SV=SPREADING VARIABLE(SV)  ******************
***   ER=EXCHANGE RANK BY VOLUME(ER)  *************
*************************************************;
**** "STEP 1" ****;
DATA FUT;SET STORE.BEHR;OBS=_N_; KH=10; KS=7; KV=7; Z0=1;
IR=UY;RR=CC;
IF TR=0 THEN TR=1;
ZZ=((SH+LH)/TR)*(1-(NR/(NR+TR)));
H=SH+LH+ZZ*NR;S=SS+LS+(1-ZZ)*NR;
KEEP T H S V TS CN FN RR CV TV LN PE AG IR NP SV ER OBS KH KS KV Z0 YR
TT CS;
TITLE1 BEHAVIOR MODEL OF FUTURES MARKETS;
TITLE2 WARD AND BEHR -- UN OF FLORIDA;

TT=YR-1960;
TV=CN**2;
CS=CV**2;
IF H=0 THEN H=1;IF S=0 THEN S=1;IF V=0 THEN V=1;
H=H/TS;S=S/TS;V=V/(TS*250);
H=((1/H)-1);S=((1/S)-1);V=((1/V)-1);
H=LOG(H);S=LOG(S);V=LOG(V);
**** "STEP 2" ****;
PROC SYSREG OUT=EDGE;
A: MODEL H=CN FN RR CV TV LN PE AG IR NP SV ER TT CS;
OUTPUT PREDICTED=HHAT;
B: MODEL S=CN FN RR CV TV LN PE AG IR NP SV ER TT CS;
OUTPUT PREDICTED=SHAT;
C: MODEL V=CN FN RR CV TV LN PE AG IR NP SV ER TT CS;
OUTPUT PREDICTED=VHAT;
```

```
PROC MATRIX;
MACRO TSCS OBS=NROW(T); NQ=0;
TI=DESIGN(T);  N=NCOL(TI);
DO II=1 TO N; TZ=SUM(TI(,II));  TT=I(TZ); EE=J(TZ,TZ,1);
A=TT#(1-RHO) + EE#RHO; AI=INV(A); FREE A EE TT; P=HALF(AI); FREE AI;
R=NQ+1; S=NQ+TZ; TY1=P*Y(R:S,); TX1=P*X(R:S,); NQ=NQ+TZ;
IF II=1 THEN TY=TY1; ELSE TY=TY//TY1;
IF II=1 THEN TX=TX1; ELSE TX=TX//TX1;  FREE TY1 TX1; END;
BETA=INV(TX'*TX)*(TX'*TY);
ERR=TY-TX*BETA; ESS=SSQ(ERR); VAR=ESS#/(OBS-(K+1));
COVB=INV(TX'*TX)#VAR; DCOVB=DIAG(COVB);
STB=SQRT(DCOVB); TTEST=BETA'*INV(STB);
STB=VECDIAG(STB);
RESULT=BETA||STB||TTEST';
ADJ=(SUM(TY)##2)#/OBS;RSQ=(BETA'*(TX'*TY)-ADJ)#/(TY'*TY-ADJ);
ZZ=((TI'*TI)#RHO)#/(1-RHO);
CONLK=((SUM(TI'*TI)#VAR#(1-RHO))+(SUM(LOG(VECDIAG(ZZ)+1))));
FREE ZZ; STATIS=RHO//CONLK//VAR//RSQ//OBS//K//ESS;
NOTE  ROW1=RHO ROW2=CONLK ROW3=VAR ROW4=RSQ ROW5=OBS ROW6=K ROW7=ESS;
PRINT STATIS;
NOTE BETA COL1=BETA  COL2=STD  COL3=T TEST;
PRINT RESULT;
%
FETCH DD DATA=FUT (KEEP=T KH KS KV);
T=DD(,1); KH=DD(1,2); KS=DD(1,3); KV=DD(1,4);FREE DD;
**** "STEP 2" ****;
FETCH EXG DATA=HEDGE (KEEP=CN FN RR CV
TV LN PE AG IR NP SV ER Z0 H S V HHAT SHAT VHAT TT CS);
**** "STEP 3" **** "ESTIMATES FOR FIRST EQUATION"****;
Y=EXG(,14);  X=EXG(,1 2 3 4 5 6 7 8 13 19 21);
DO RHO1=0 TO .9 BY .1;
K=KH; RHO=RHO1; NOTE SKIP=3  ------ HEDGING EQUATION -----;
 TSCS IF RHO1=0 THEN DO; HRHO=RHO1; HCON=CONLK; HY=TY; HX=TX; END;
IF HCON>CONLK THEN DO; HRHO=RHO1; HCON=CONLK; HY=TY; HX=TX; END;
END;

**** "STEP 3" **** "ESTIMATE FOR SECOND EQUATION" ****;
Y=EXG(,15); X=EXG(,4 7 8 9 11 13 19 21);
DO RHO2=0 TO .9 BY .1;
K=KS;RHO=RHO2;NOTE SKIP=3 ------  SPECULATION EQUATION ------;
TSCS IF RHO2=0 THEN DO; SRHO=RHO2; SCON=CONLK; SY=TY; SX=TX; END;
IF SCON>CONLK THEN DO; SRHO=RHO2; SCON=CONLK; SY=TY; SX=TX; END;
END;

**** "STEP 3" **** "ESTIMATE FOR THIRD EQUATION" ****;
Y=EXG(,16);  X=EXG(,7 10 11 12 13 17 18 20);
DO RHO3=0 TO .9 BY .1;
K=KV; RHO=RHO3; NOTE SKIP=3  ------  VOLUME EQUATION ------;
TSCS IF RHO3=0 THEN DO; VRHO=RHO3; VCON=CONLK; VY=TY; VX=TX; END;
IF VCON>CONLK THEN DO; VCON=CONLK; VRHO=RHO3; VY=TY; VX=TX; END;
END;
ENDOG=HY||SY||VY; OUTPUT ENDOG OUT=FUT1
(RENAME=(COL1=HDG COL2=SPC COL3=VOL));
```

```
**** "STEP 4" ****;
OUTPUT HX OUT=FUT2
(RENAME=(COL1=HCN COL2=HFN COL3=HRR COL4=HCV
COL5=HTV COL6=HLN COL7=HPE COL8=HAG COL9=HINT
COL10=HVHAT COL11=HCS));

**** "STEP 4" ****;
OUTPUT SX OUT=FUT3
(RENAME=(COL1=SCV COL2=SPE COL3=SAG COL4=SIR COL5=SSV
COL6=SINT COL7=SVHAT COL8=SCS));

**** "STEP 4" ****;
OUTPUT VX OUT=FUT4
(RENAME=(COL1=VPE COL2=VNP COL3=VSV COL4=VER COL5=VINT
COL6=VHHAT COL7=VSHAT COL8=VTT));

NOTE ------ CROSS SECTIONAL-TIME SERIES ADJUSTMENTS ------;
PRINT HRHO SRHO VRHO HCON SCON VCON;
DATA; MERGE FUT1 FUT2 FUT3 FUT4;
TITLE3 SEEMINGLY UNRELATED REGRESSION;
TITLE4 THIRD STAGE RESULTS;

**** "STEP 5" ****;
PROC SYSREG;
H: MODEL HOG=HCN HFN HRR HCV HTV HLN HPE HAG HVHAT HINT HCS
  /COV8 DW NOINT;
S: MODEL SPC=SCV SPE SAG SIR SSV SVHAT SINT SCS
  /COV8 DW NOINT;
V: MODEL VOL=VPE VNP VSV VER VHHAT VSHAT VINT VTT
  /COV8 DW NOINT;
B: SYSTEM H S V;

END OF FILE ON SYSIN.
```

APPENDIX G

RELATIONSHIP BETWEEN NET BENEFIT FUNCTION AND MATHEMATICAL MODEL[a]

[a] See equations 4.23, 4.24, and 4.25.

The net benefit function is explicitly defined as follows:

$$(G.1)\quad N = \delta_1 \log\left(\frac{1}{H^*} - 1\right) + \delta_{11}\left(\log\left(\frac{1}{H^*} - 1\right)\right)^2 + \delta_2 \log\left(\frac{1}{S^*} - 1\right) + \delta_{22}\left(\log\left(\frac{1}{S^*} - 1\right)\right)^2 + \delta_3 \log\left(\frac{1}{V^*} - 1\right) + \delta_{33}\left(\log\left(\frac{1}{V^*} - 1\right)\right)^2 + \delta_{13}\log\left(\frac{1}{H^*} - 1\right)\log\left(\frac{1}{V^*} - 1\right) + \delta_{23}\log\left(\frac{1}{S^*} - 1\right)\log\left(\frac{1}{V^*} - 1\right) + \delta_{12}\log\left(\frac{1}{H^*} - 1\right)\log\left(\frac{1}{S^*} - 1\right) + \sum_{i=1}^{14} \gamma_{1i}\log\left(\frac{1}{H^*} - 1\right) \cdot X_i + \sum_{i=1}^{14} \gamma_{2i}\log\left(\frac{1}{S^*} - 1\right) \cdot X_i + \sum_{i=1}^{14} \gamma_{3i}\log\left(\frac{1}{V^*} - 1\right) \cdot X_i$$

where H^* = hedging open interest expressed as a percent of total supply,

S^* = speculation open interest expressed as a percent of total supply,

V^* = volume expressed as a percent of total supply,

X_i = exogneous variables of the model (see Table 6.6).

Partially differentiating G.1 with respect to H^* and setting the result equal to zero yields the following:

$$(G.2)\quad \frac{\partial N}{\partial H} = \delta_1\left(\frac{-1}{H^{*2}}\right)\left(\frac{H^*}{1-H^*}\right) + 2\delta_{11}\log\left(\frac{1}{H^*} - 1\right)\left(\frac{-1}{H^{*2}}\right)\left(\frac{H^*}{1-H^*}\right) + \delta_{12}\log\left(\frac{1}{S^*} - 1\right)\left(\frac{-1}{H^{*2}}\right)\left(\frac{H^*}{1-H^*}\right) + \delta_{13}\log\left(\frac{1}{V^*} - 1\right)\left(\frac{-1}{H^{*2}}\right)\left(\frac{H^*}{1-H^*}\right) + \sum_{i=1}^{14} \gamma_{1i} X_i \left(\frac{-1}{H^{*2}}\right)\left(\frac{H^*}{1-H^*}\right) = 0$$

Rewriting G.2, expressing $\log\left(\frac{1}{H^*} - 1\right)$ as the dependent variable, results in the following:

$$(G.3)\quad \log\left(\frac{1}{H^*} - 1\right) = \frac{-\delta_1}{2\delta_{11}} - \frac{\delta_{12}}{2\delta_{11}}\log\left(\frac{1}{S^*} - 1\right) - \frac{\delta_{13}}{2\delta_{11}}\log\left(\frac{1}{V^*} - 1\right) - \sum_{i=1}^{14} \frac{\gamma_{1i}}{2\delta_{11}} X_i$$

Similarly, the first order conditions with respect to S* and V* are given by

$$(G.4)\quad \log\left(\frac{1}{S^*} - 1\right) = \frac{-\delta_2}{2\delta_{22}} - \frac{\delta_{12}}{2\delta_{22}} \log\left(\frac{1}{H^*} - 1\right) - \frac{\delta_{23}}{2\delta_{22}} \log\left(\frac{1}{V^*} - 1\right) - \sum_{i=1}^{14} \frac{\gamma_{2i}}{2\delta_{22}} X_i$$

$$(G.5)\quad \log\left(\frac{1}{V^*} - 1\right) = \frac{-\delta_3}{2\delta_{33}} - \frac{\delta_{13}}{2\delta_{33}} \log\left(\frac{1}{H^*} - 1\right) - \frac{\delta_{23}}{2\delta_{33}} \log\left(\frac{1}{S^*} - 1\right) - \sum_{i=1}^{14} \frac{\gamma_{3i}}{2\delta_{33}} X_i$$

Since $\log\left(\frac{1}{H^*} - 1\right)$, $\log\left(\frac{1}{S^*} - 1\right)$ and $\log\left(\frac{1}{V^*} - 1\right)$ equal H, S, and V respectively, the equivalence of 6.3, 6.4, and 6.5 with 4.23, 4.24, and 4.25 is readily apparent. Also the empirical counterpart to G.3, G.4, and G.5 is seen in tables 5.5 and 5.6.

REFERENCES

Association of Commodity Exchange Firms, Inc. Bulletins 988 and 1564. New York.

Blau, Gerda. "Some Aspects of the Theory of Futures Trading." Rev. Econ. Stud. 12(1944):1-30.

Brennan, M.J. "The Supply of Storage." Amer. Econ. Rev. 48(1958):50-72.

Chiang, A.C. Fundamental Methods of Mathematical Economics. New York: McGraw-Hill, 1974.

Chicago Mercantile Exchange. Yearbook, annual, 1969-1978.

Commodity Year Book. Commodity Research Bureau, Inc., annual, 1961-1978. New York.

Dale, C. "The Hedging Effectivess of Currency Futures Markets." J. Fut. Mkts. 1(1981):77-88.

Data Book 1978. Commodity Futures Trading Commission. (Commitments of traders). Washington, D.C.

Dhrymes, P.J. Econometrics. New York: Springer-Verlag, 1974.

Florida Citrus Mutual. Annual Statistical Report, Annual, 1969-1978.

Friedman, M. Essays in Positive Economics. Chicago: Chicago University Press, 1953.

Futures Industry Association, Inc. Volume Statistics 1975-1979, Washington, D.C.

Gray, R.W. "Why Futures Markets Succeed or Fail." Futures Trading Seminar. 3(1966):115-137.

Gray, R.W. "Price Effects of a Lack of Speculation." Food Res. Inst. Stud. Supplement, 7(1967):177-94.

Gray, R.W. and D.J.S. Rutledge. "The Economics of Commodity Futures Markets: A Survey Review of Marketing and Agricultural Economics." Rev. Mktg. Agr. Econ. 39(1971):57-108.

Hayenga, M.L. Pricing Problems in the Food Industry. North Central Regional Research Project NC-117 Monograph No.7. University of Wisconsin, Madison (1979).

Hieronymus, T.A. Economics of Futures Trading. New York: Commodity Research Bureau, Inc., 1971.

Higinbotham, H.N. The Demand for Hedging in Grain Futures Markets. University of Chicago: Ph.D. dissertation, 1976.

Hoffman, G.W. Futures Trading upon Organized Commodity Markets in the United States. Philadelphia: University of Pennsylvania Press, 1932.

Houthakker, A. "Can Speculators Forecast Prices." Rev. Econ. Stat. 39 (1951):141-153.

Irwin, H.S. Evolution of Futures Trading. Madison, Wisconsin: Mimir, 1954.

Judge, G.J., Griffiths, W.E., Hill, R.C., and T. Lee. The Theory and Practice of Econometrics. New York: Wiley, 1980.

Kaldor, N. "Speculation and Economic Stability." Rev. Econ. Stud. 7 (1939):196-201.

Keynes, J.M. "Some Aspects of Commodity Markets." Manchester Guardian Commercial (European Reconstruction Series). March 29, 1923, pp. 784-786.

Keynes, J.M. A Treatise on Money. New York: Harcourt, 1930.

Kmenta, J. Elements of Econometrics. New York: Macmillan, 1971.

Larson, A.B. "Estimation of Hedging and Speculative Position in Futures Markets." Food Res. Inst. Stud. 2(1961):203-212.

Leuthold, R.M. Actual and Potential Use of Livestock Futures Markets By Illinois Producers. Department of Agricultural Economics, Agricultural Experiment Station: University of Illinois, December 1975.

Maddala, G.S. Econometrics. New York: McGraw-Hill, 1977.

Nerlove, M. "Further Evidence on the Estimation of Dynamic Economic Relations From a Time Series of Cross Sections." Econometrica 39(1971):359-382.

Paul, A.B. "Treatment of Hedging in Commodity Market Regulation." ERS-USDA Technical Bulletin No. 1538, April 1976.

Paul, A.B. and W.T. Wesson. "The Futures of Futures Trading in Our Changing Agriculture." Futures Trading Seminar 1(1960):203-244.

Paul, A.B. and W.T. Wesson. "Pricing Feedlot Services Through Cattle Futures." Agr. Econ. Res. 19(1967):33-45.

Peck, A.E. "Hedging and Income Stability: Concepts, Implications, and an Example." Amer. J. Agr. Econ. 57(1975):410-429.

Powers, M.J. "Effects of Contract Provisions on the Success of a Futures Contract." J. Farm Econ. 49(1967):833-843.

Rockwell, C.S. "Normal Backwardation, Forecasting and the Returns to Speculators." Food Res. Inst. Stud. Supplement 7(1967):107-130.

Rutledge, D.J.S. "Hedgers' Demand for Futures Contract: A Theoretical Framework with Applications to the U.S. Soybean Complex." Food Res. Inst. Stud. 11(1972):237-252.

Rutledge, D.J.S. "Estimation of Hedging and Speculative Positions in Futures Markets: An Alternative Approach." Food Res. Inst. Stud. 16(1977):205-211.

Samuelson, P.A. "Proof that Properly Anticipated Prices Fluctuate Randomly." Indust. Mgmt. Rev. 6(1965):41-50.

Smidt, S. "A Test of the Serial Independence of Price Changes in Soybean Futures." Food Res. Inst. Stud. 4(1965):117-136.

Stewart, B. "An Analysis of Speculative Trading in Grain Futures." USDA Technical Bulletin No. 1001, October 1949.

Telser, L.G. "Reasons for Having an Organized Futures Market." Livestock Futures Research Symposium - CME (1980):11-67.

Telser, L.G. and H.N. Higinbotham. "Organized Futures Markets: Costs and Benefits." J. Pol. Econ. 85(1977):969-1000.

Tomek, W.G. and R.W. Gray. "Temporal Relationships Among Prices on Commodity Futures Markets: Their Allocative and Stabilizing Roles." Amer. J. Agr. Econ. 52(1970):372-380.

U.S. Department of Agriculture, Commodity Exchange Authority. Annual Summary of Commodity Futures Statistics. Annual, 1961-1973.

U.S. Department of Agriculture, Market Structure of the Food Industries. Marketing Research Report No. 971, 1972.

U.S. Department of Commerce, Bureau of Economic Analysis. Survey of Current Business. Annual, 1961-1978.

U.S. Department of Commerce, Bureau of the Census. Concentration Ratios in Manufacturing. 1972.

U.S. Department of Commerce, Bureau of the Census. Census of Manufactures. 1977.

Wall Street Journal. New York: Dow Jones, monthly issues, 1973-1978.

Ward, R.W. "Market Liquidity in the FCOJ Futures Market." Amer. J. Agr. Econ. 56(1974):150-154.

Ward, R.W. and L.B. Fletcher. "From Hedging to Pure Speculation: A Micro Model of Optimal Futures and Cash Market Positions." Amer. J. Agr. Econ. 53(1971):71-78.

Ward, R.W. and J.A. Niles. Hedging Strategies in FCOJ Futures. Economic Research Report No. 75-1: Food and Resource Economics Department, University of Florida, 1975.

Ward, R.W. and G. Schimkat. "Risk Ratios and Hedging: Florida Feeder Cattle." South J. Agr. Econ. 11(1979):71-78.

Working, H. "The Theory of Price of Storage." Amer. Econ. Rev. 39(1949): 1254-1262.

Working, H. "Hedging Reconsidered." J. Farm Econ. 35(1953):544-561.

Working, H. "Whose Markets? Evidence on Some Aspects of Futures Trading." J. Mktg. 19(1954):1-11.

Working, H. "A Theory of Anticipatory Prices." Amer. Econ. Rev. 48 (1958):188-199.

Working, H. "Speculation on Hedging Markets." Food Res. Inst. Stud. 1(1960):185-270.

Working, H. "New Concepts Concerning Futures Markets and Prices." Amer. Econ. Rev. 52(1962):431-459.

BIOGRAPHICAL SKETCH

Robert M. Behr was born March 11, 1954, to Norman and Sheila Behr in the then "City Beautiful" Orlando, Florida. Central Florida was Bob's stomping ground throughout his early years.

In 1973 Bob met his destiny by becoming a Florida Gator as he enrolled as a freshman at the University of Florida. It was there that economic thought began to shape his mind. In 1974 he transferred to the University of Arizona where a B.S. in economics was earned in 1976.

Upon graduation Bob reenrolled at the University of Florida to do graduate work. During this period he met the former Sarah Miller and obtained all her worldly goods. In his spare time, working under the guidance of Dr. Ron Ward, Bob pursued a doctoral degree in food and resource economics. The dissertation herein is proof that the degree was actually completed.

I certify that I have read this study and that in my opinion it conforms to acceptable standards of scholarly presentation and is fully adequate, in scope and quality, as a dissertation for the degree of Doctor of Philosophy.

Ronald Ward

Ronald Ward, Chairman
Professor of Food and Resource Economics

I certify that I have read this study and that in my opinion it conforms to acceptable standards of scholarly presentation and is fully adequate, in scope and quality, as a dissertation for the degree of Doctor of Philosophy.

Leo Polopolus

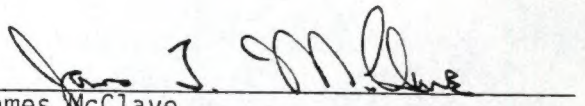
Leo Polopolus
Professor of Food and Resource Economics

I certify that I have read this study and that in my opinion it conforms to acceptable standards of scholarly presentation and is fully adequate, in scope and quality, as a dissertation for the degree of Doctor of Philosophy.

Richard A. Kilmer

Richard Kilmer
Assistant Professor of Food and Resource Economics

I certify that I have read this study and that in my opinion it conforms to acceptable standards of scholarly presentation and is fully adequate, in scope and quality, as a dissertation for the degree of Doctor of Philosophy.



James McClave
Associate Professor of Statistics

This dissertation was submitted to the Graduate Faculty of the College of Agriculture and to the Graduate Council, and was accepted as partial fulfillment of the requirements for the degree of Doctor of Philosophy.

June 1981

Dean, College of Agriculture

Dean for Graduate Studies and Research

UNIVERSITY OF FLORIDA
3 1262 08553 9574